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Suzuki

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(54) **IMAGING STAND**

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H05G 1/02 (2006.01)
A61B 6/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 6/4233*** (2013.01); ***A61B 6/4283*** (2013.01); ***A61B 6/4429*** (2013.01); ***A61B 6/547*** (2013.01); *A61B 6/40* (2013.01); *A61B 6/542* (2013.01); *A61B 6/588* (2013.01)

(58) **Field of Classification Search**
CPC A61B 6/4441; G03B 42/025
USPC 248/161, 162.1, 411, 157, 420, 422; 378/193, 195, 196, 197
See application file for complete search history.

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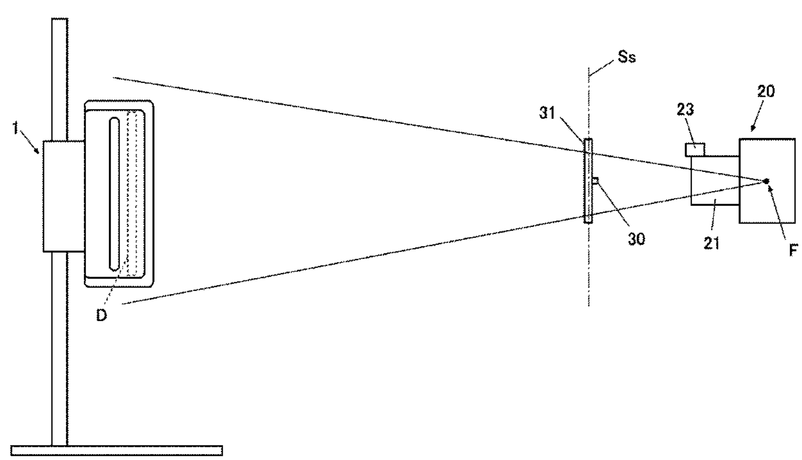
(57) **ABSTRACT**

An imaging stand includes: a holder configured to hold an installed cassette-type detector; a supporting member configured to support the holder from a back surface side; a circular gear secured to a shaft member protruding from a rotation center of the holder toward the supporting member on the back surface side, the holder being located in a different position from a position corresponding to the center of a radiation incidence surface of the cassette-type detector held in the holder; and a linear gear having concavities and convexities to be engaged with teeth of the circular gear, the linear gear being attached to the supporting member, wherein, when the holder holding the cassette-type detector is rotated relative to the supporting member, the rotation center of the holder linearly moves relative to the supporting member as the holder rotates, and a change is caused in orientation and position of the cassette-type detector.

10 Claims, 28 Drawing Sheets



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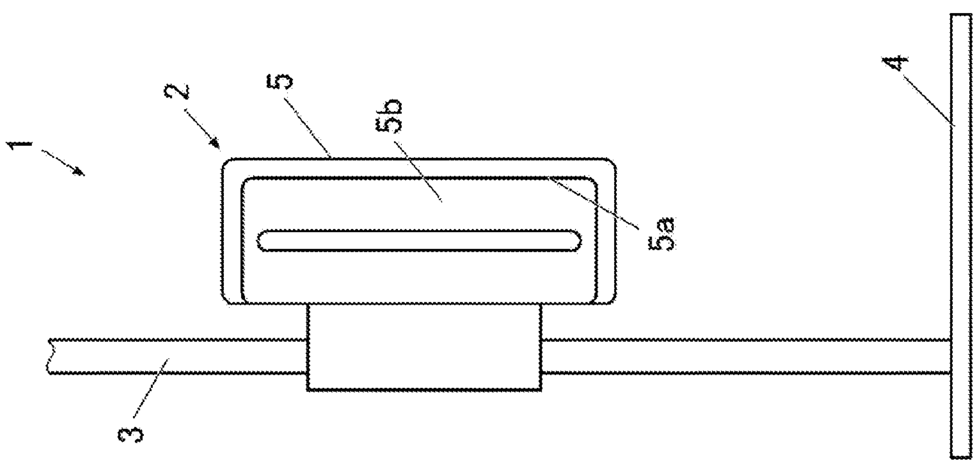


FIG. 1B

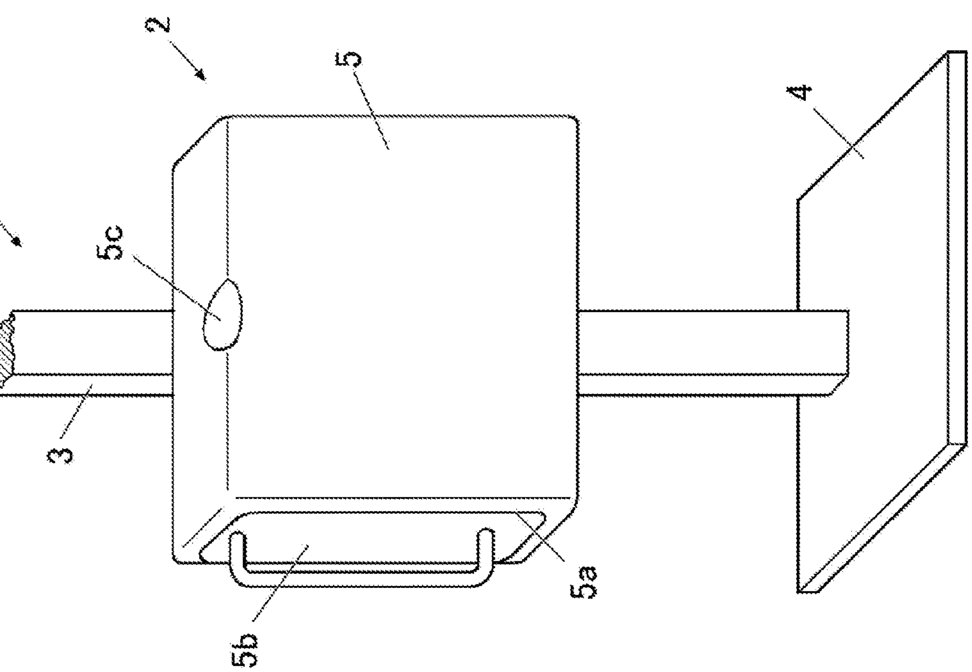


FIG. 1A

FIG. 2

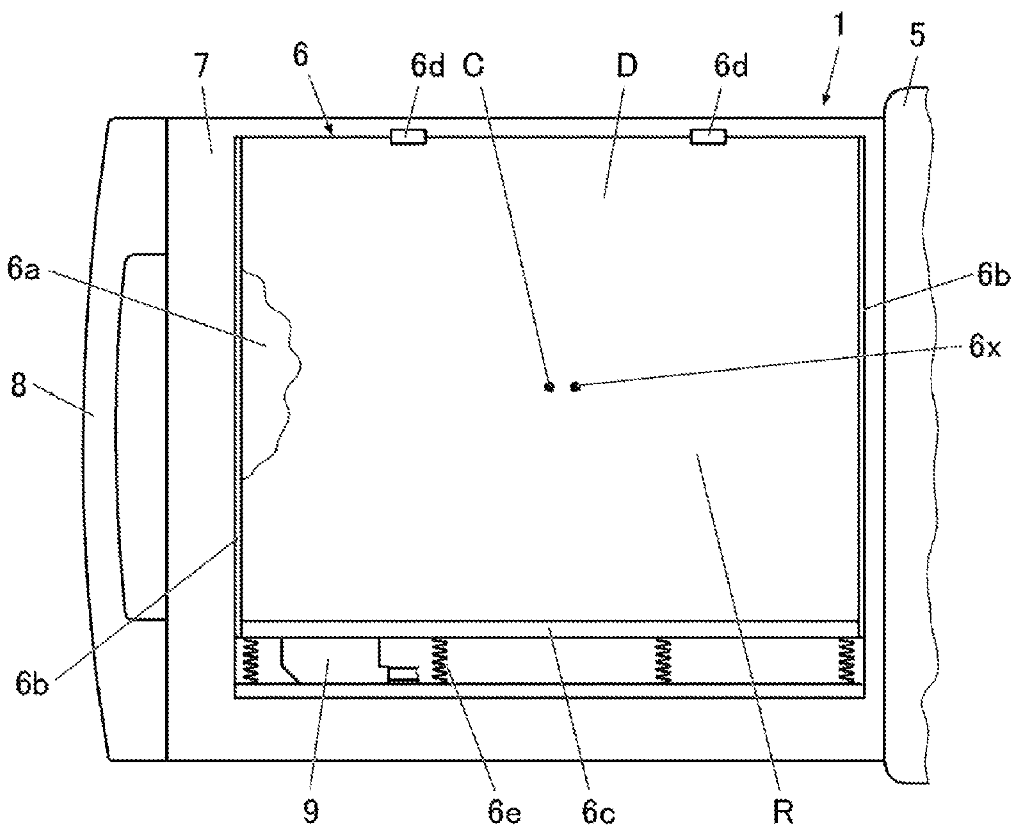


FIG. 3A

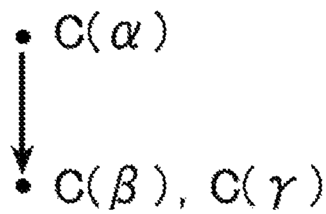


FIG. 3B

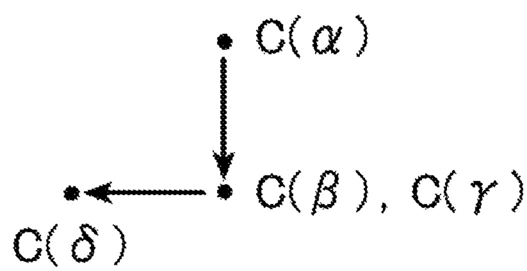


FIG. 4

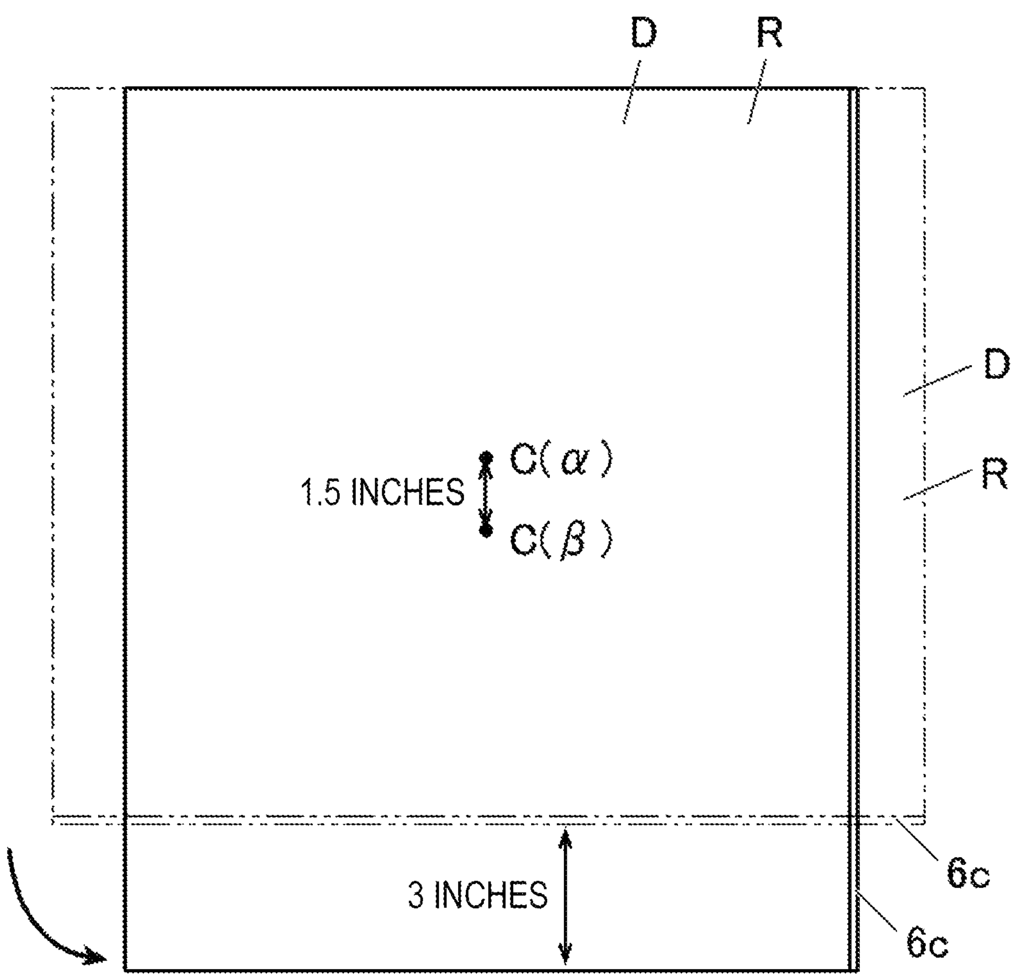


FIG. 5

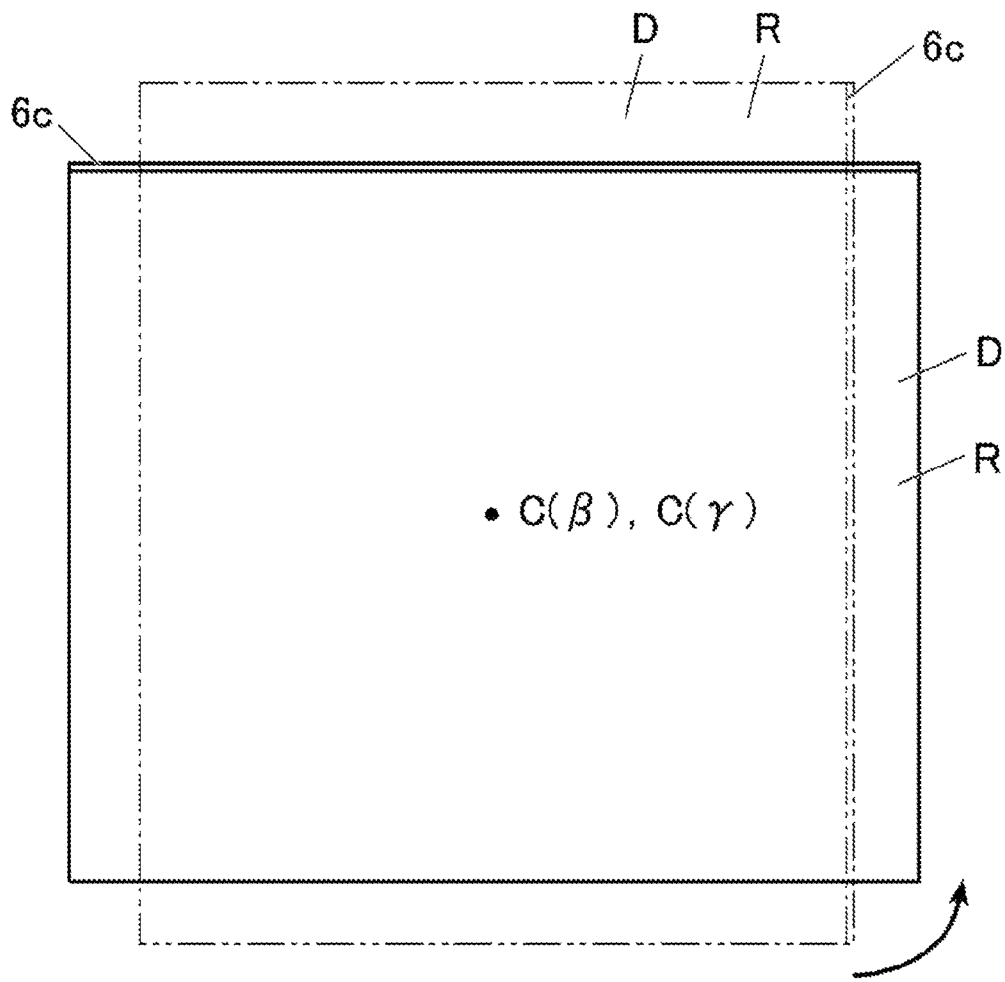


FIG. 6

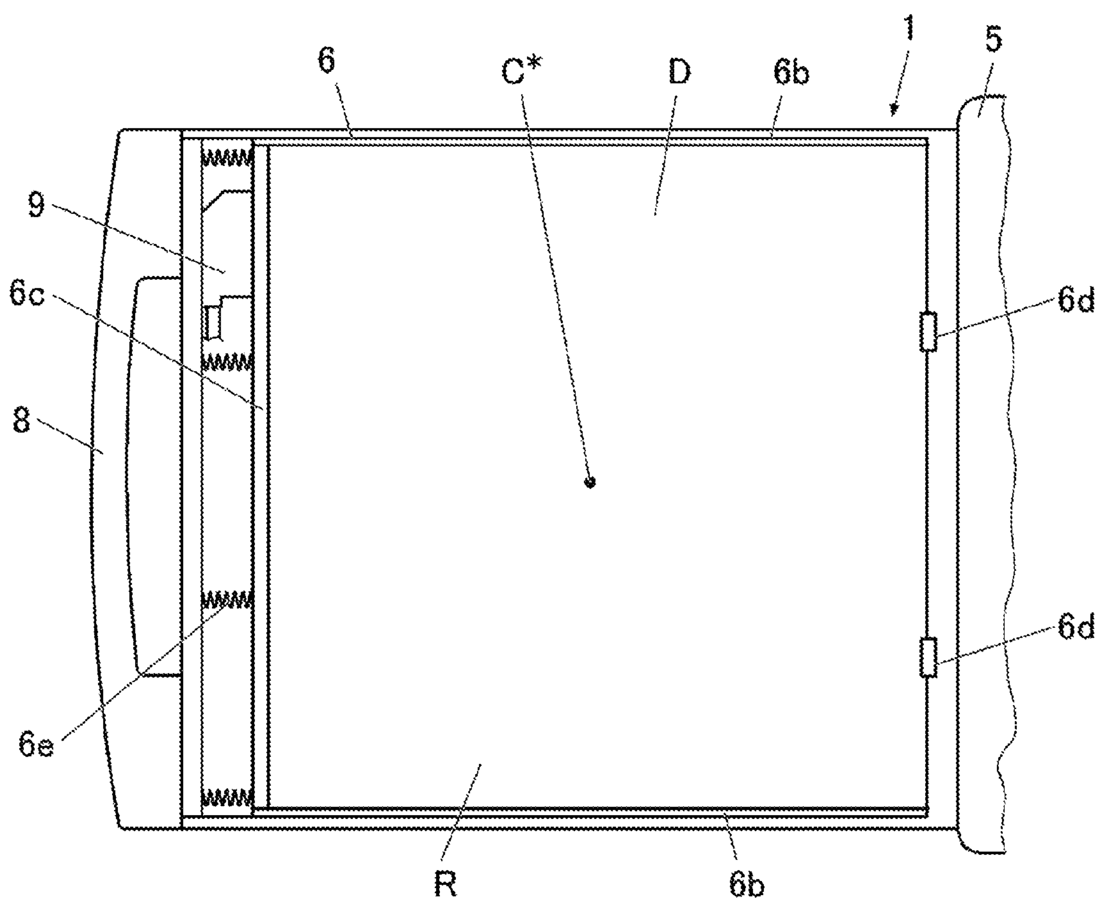


FIG. 7

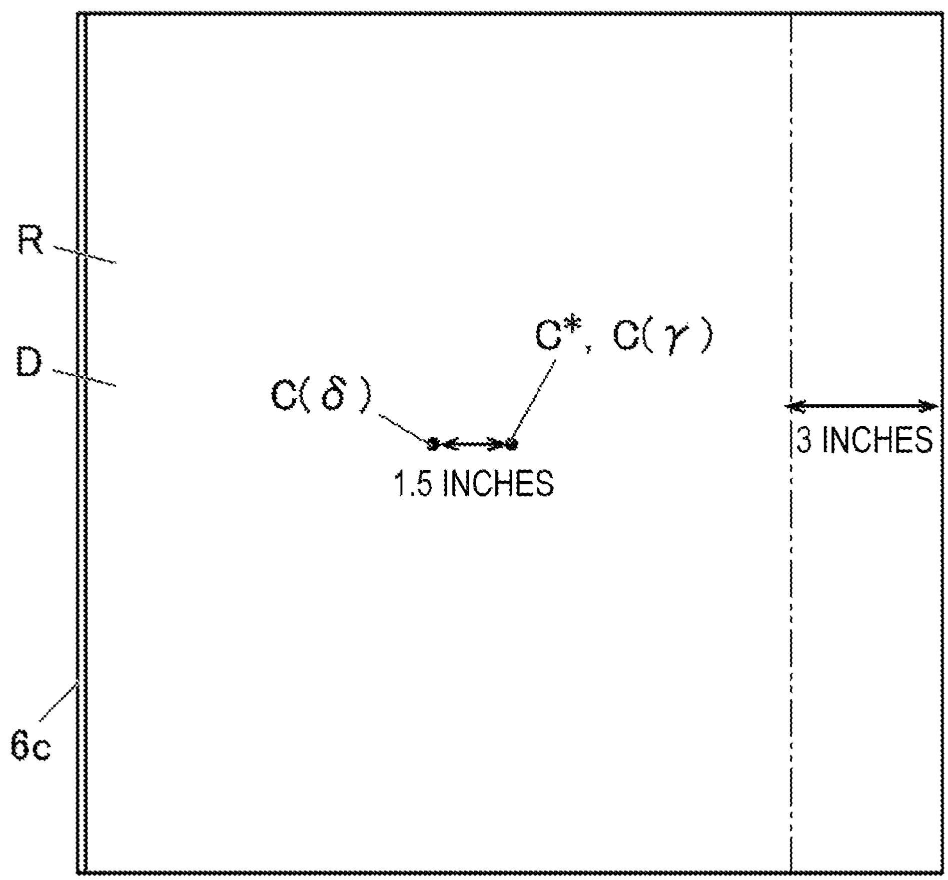


FIG. 8

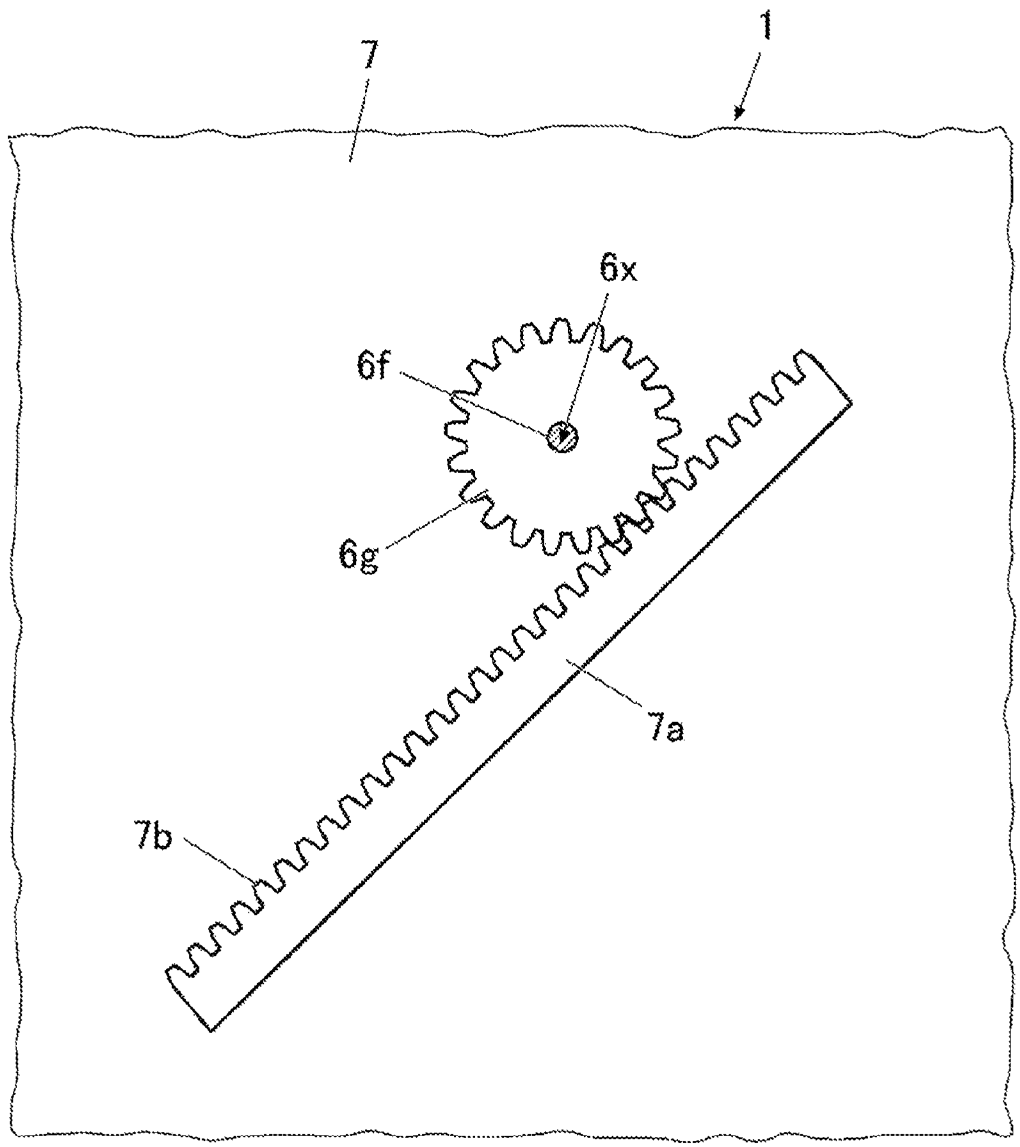


FIG. 9A

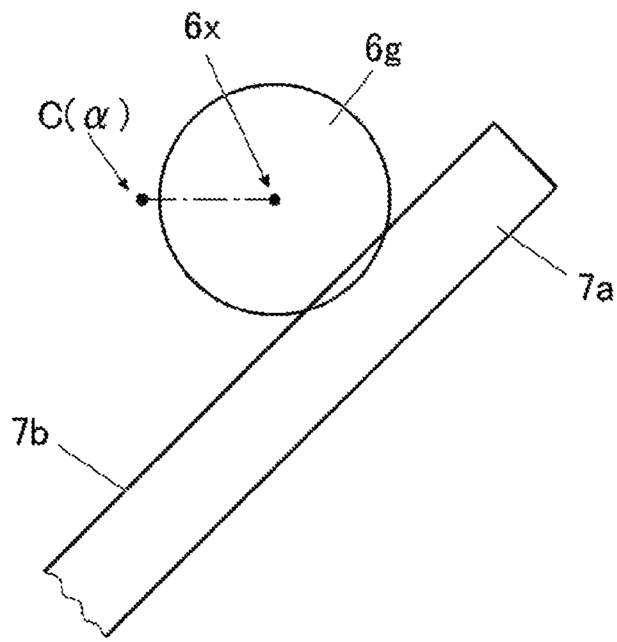


FIG. 9B

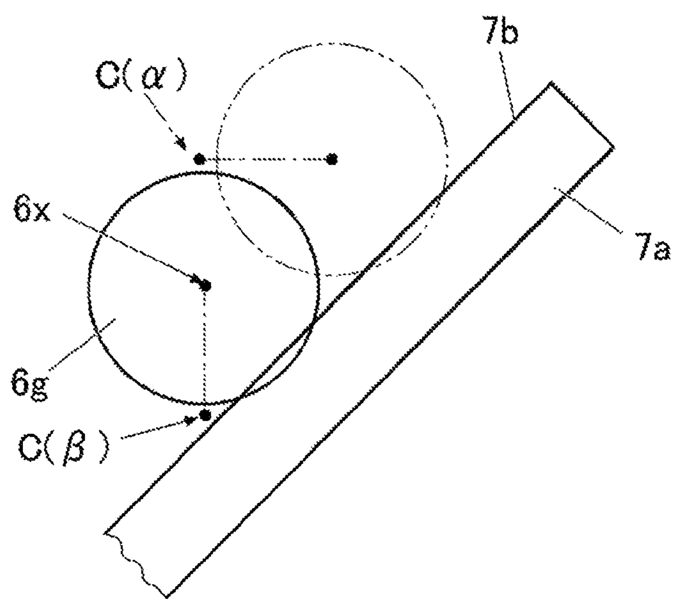


FIG. 10A

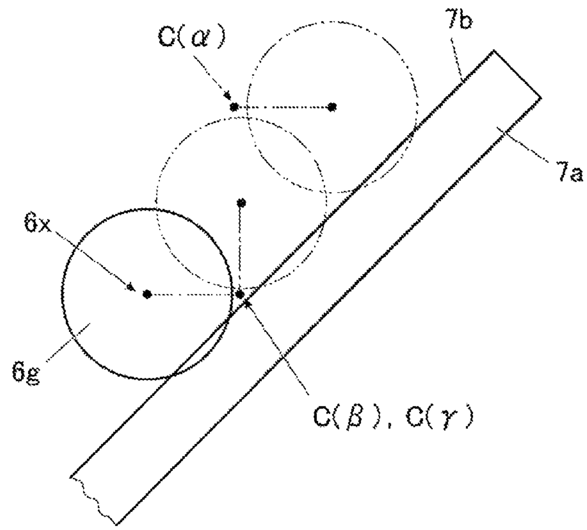


FIG. 10B

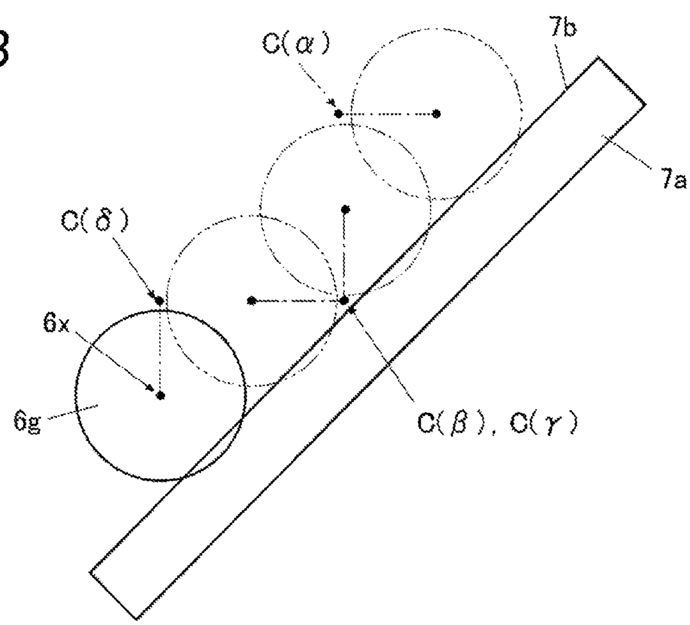


FIG. 11

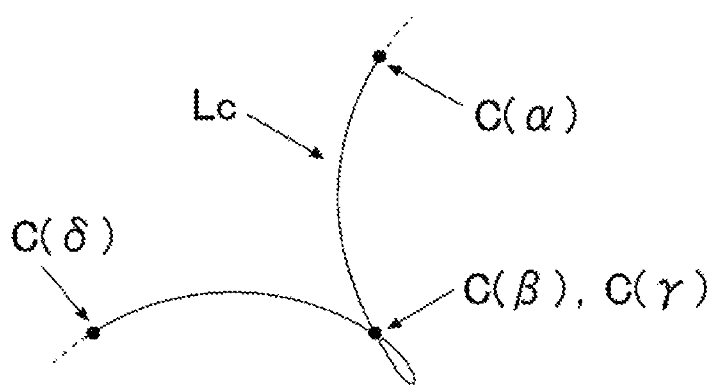


FIG. 12

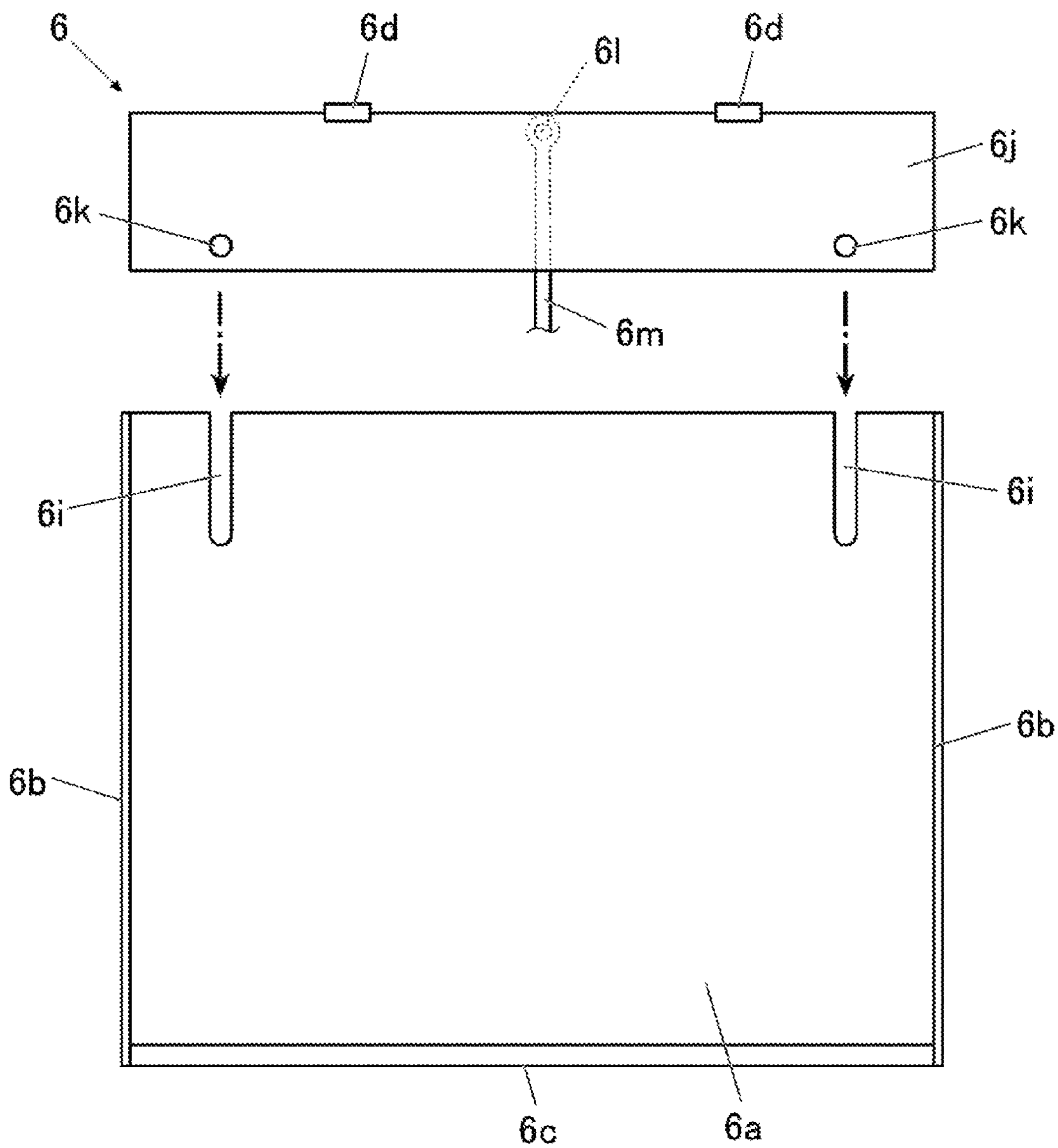


FIG. 13

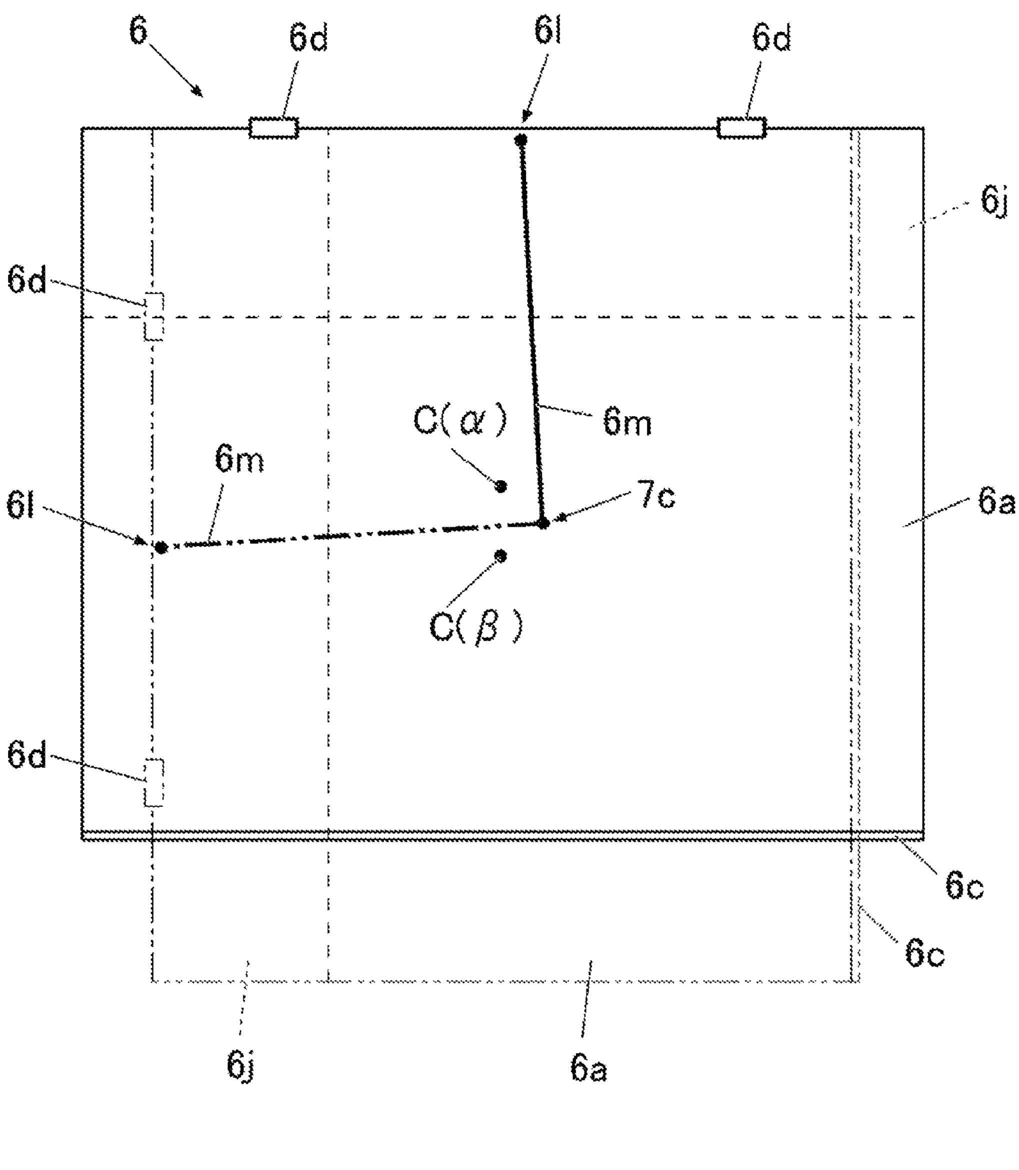


FIG. 14

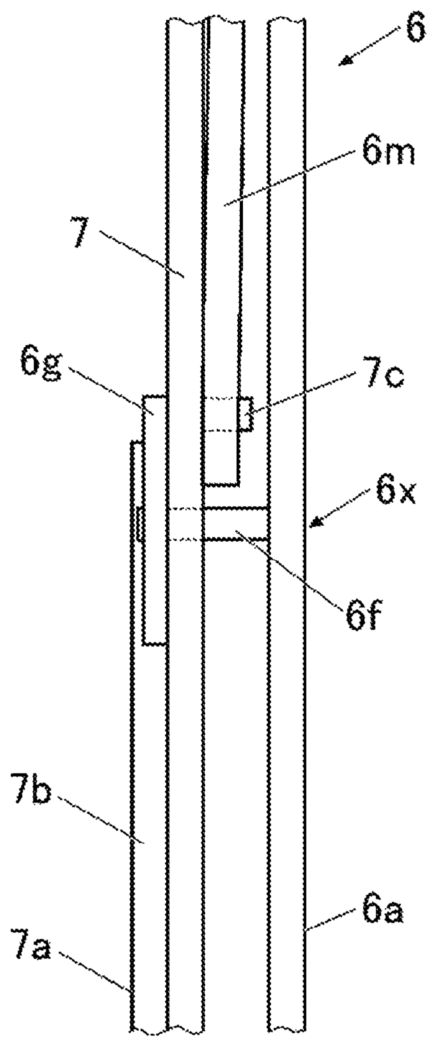


FIG. 15

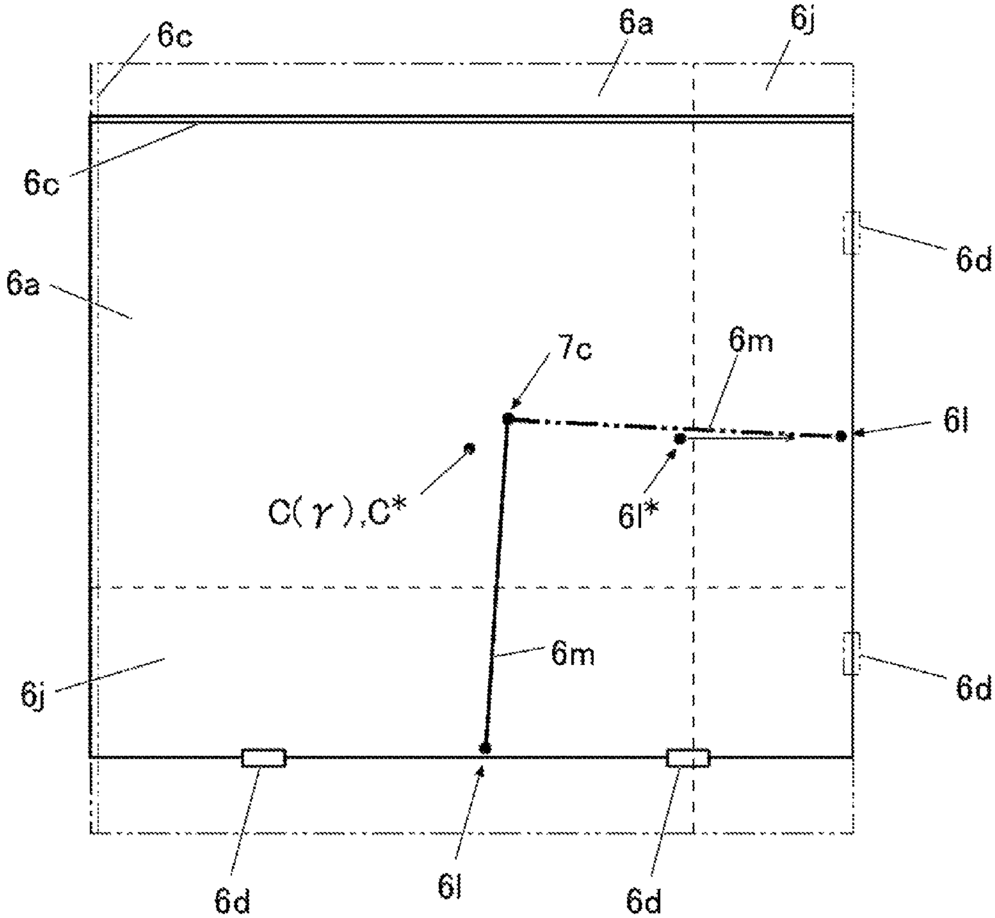


FIG. 16A

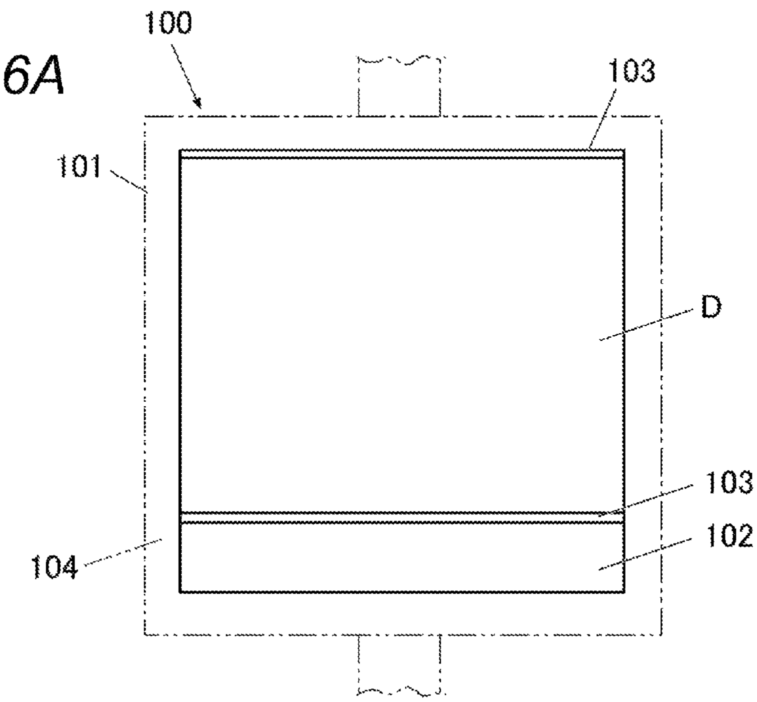


FIG. 16B

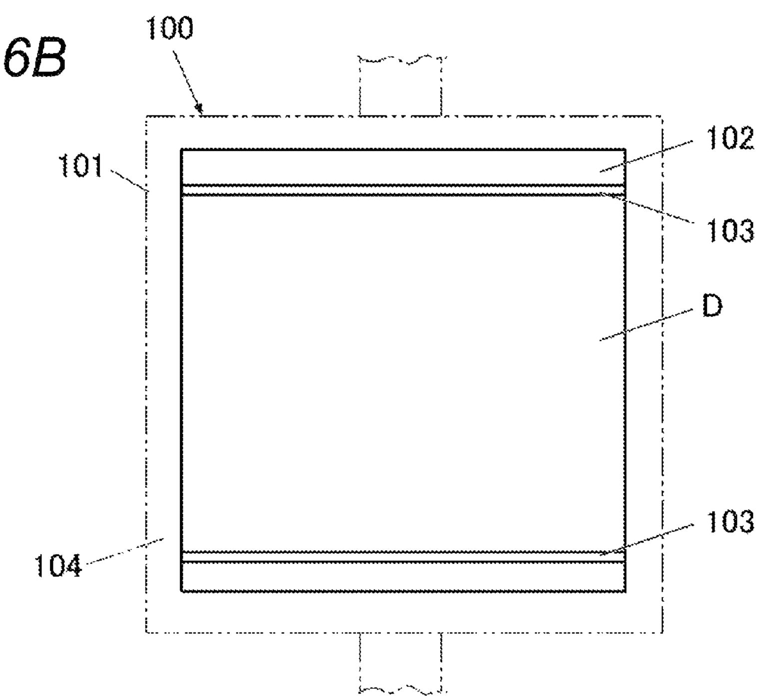


FIG. 17A

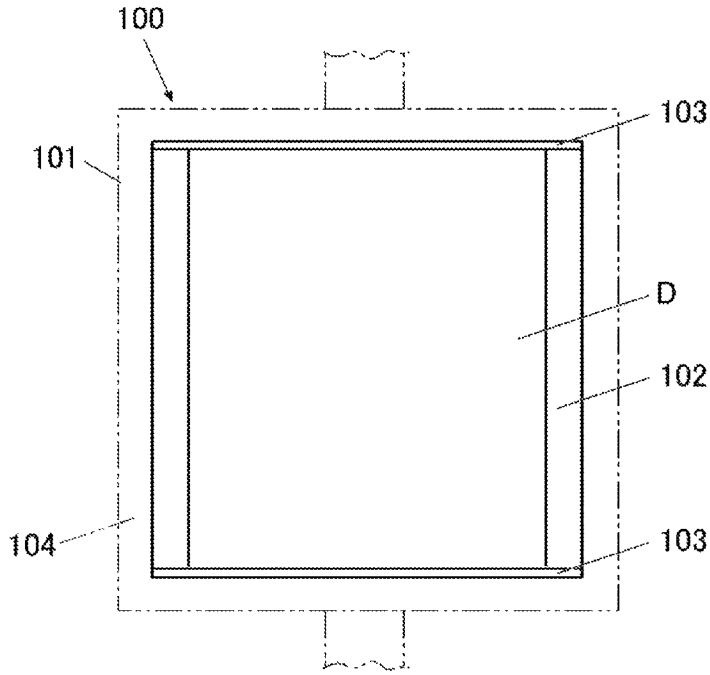


FIG. 17B

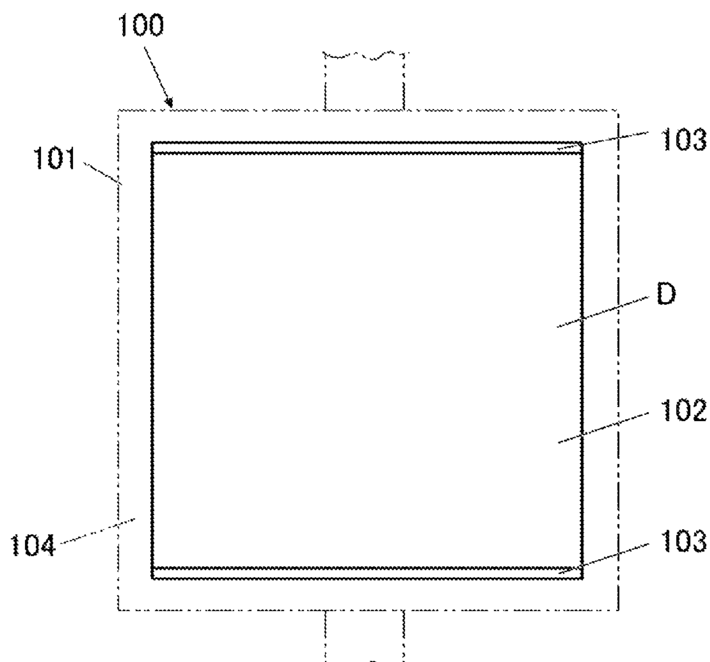


FIG. 18

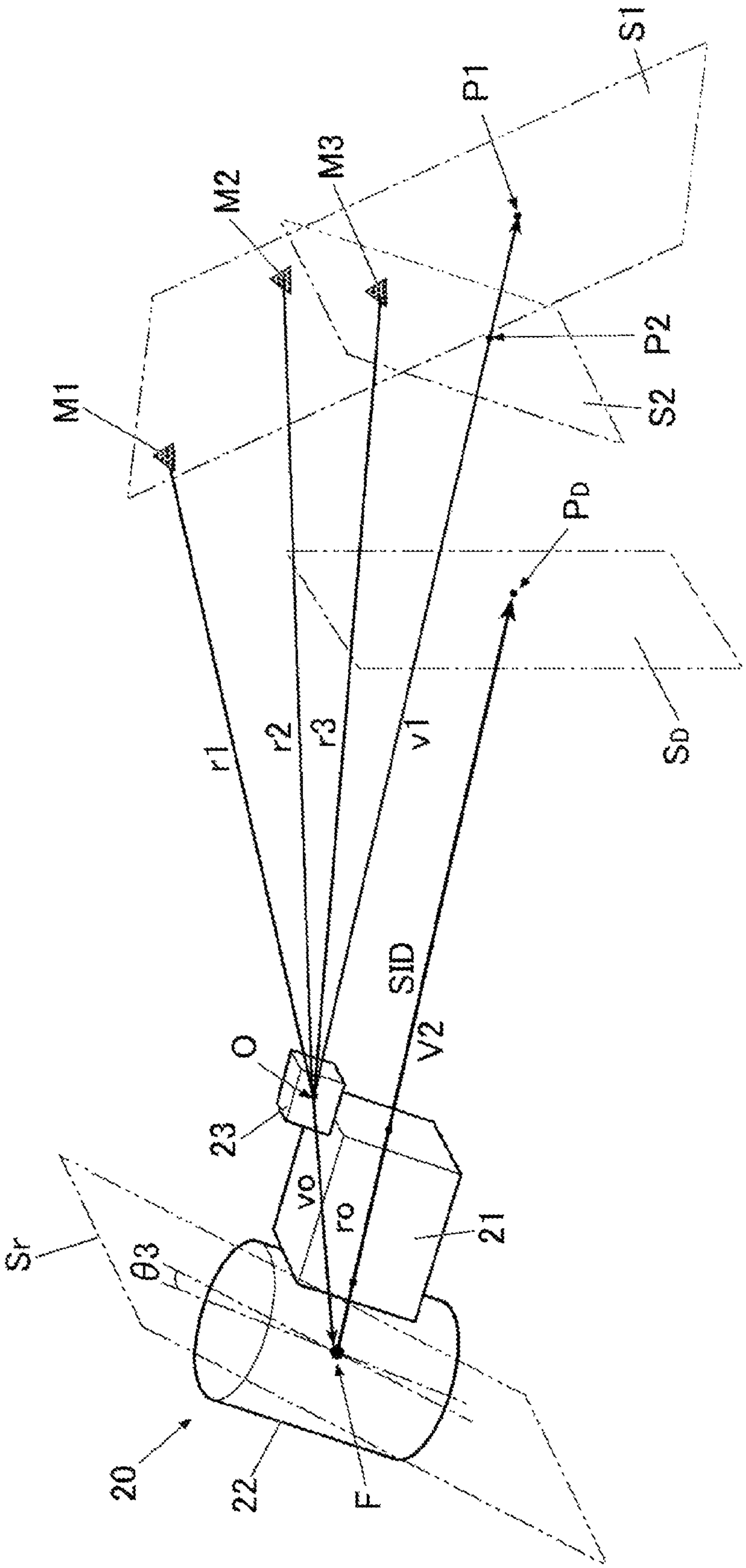


FIG. 19

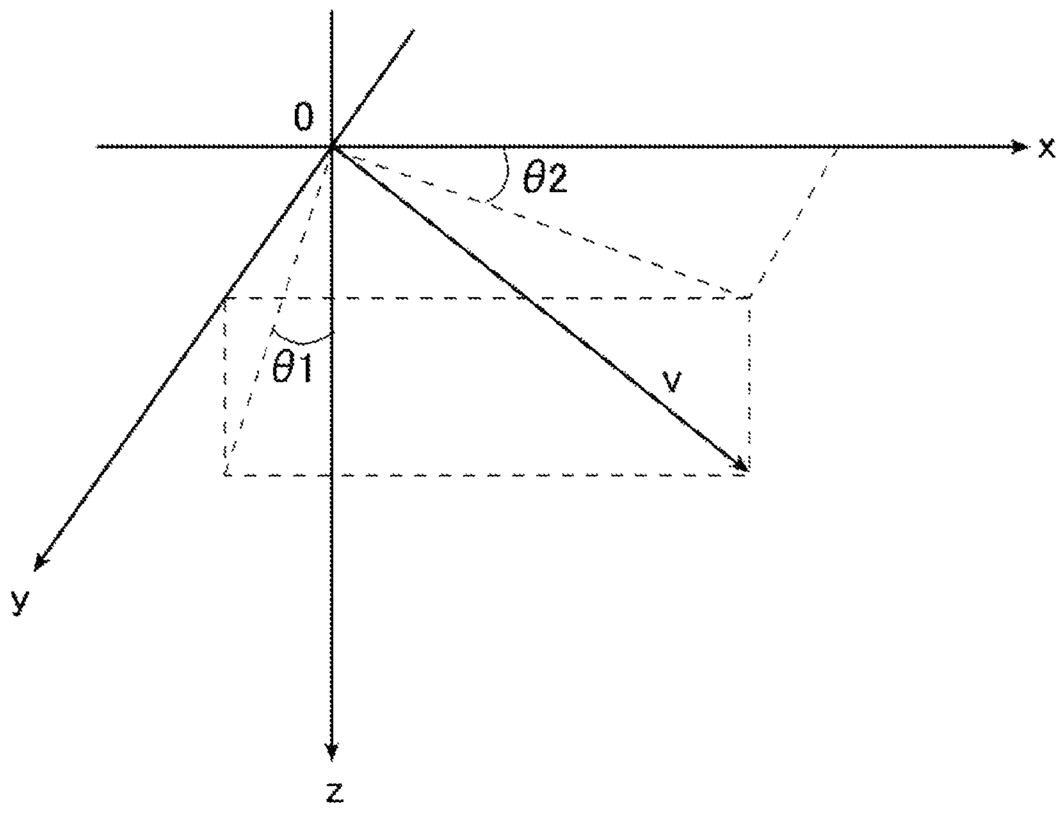


FIG. 20

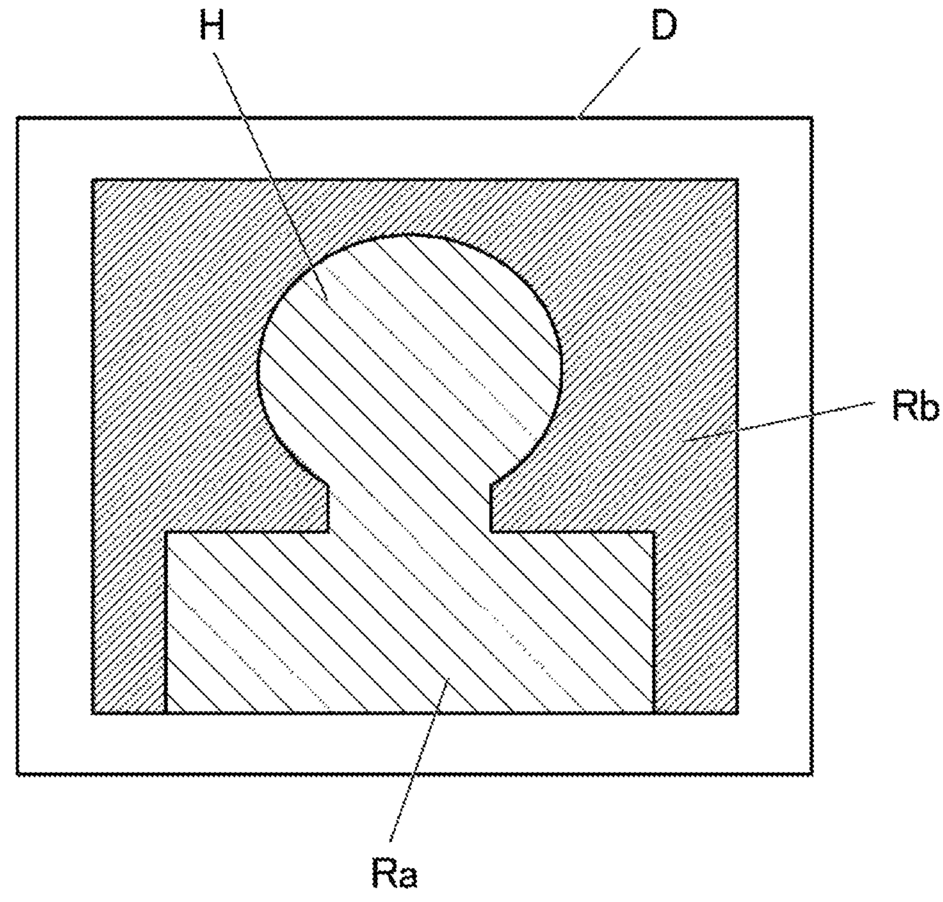


FIG. 21

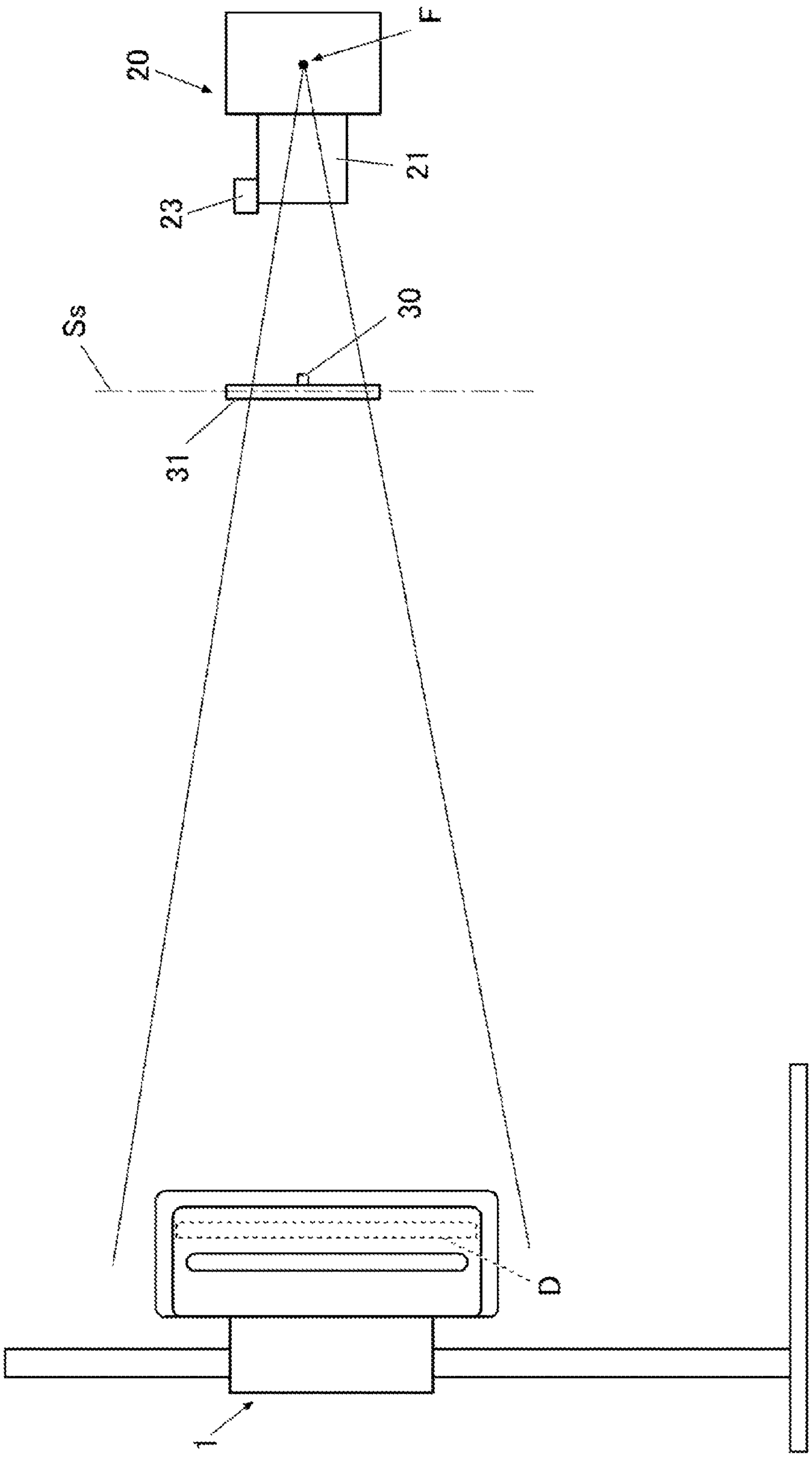


FIG. 22

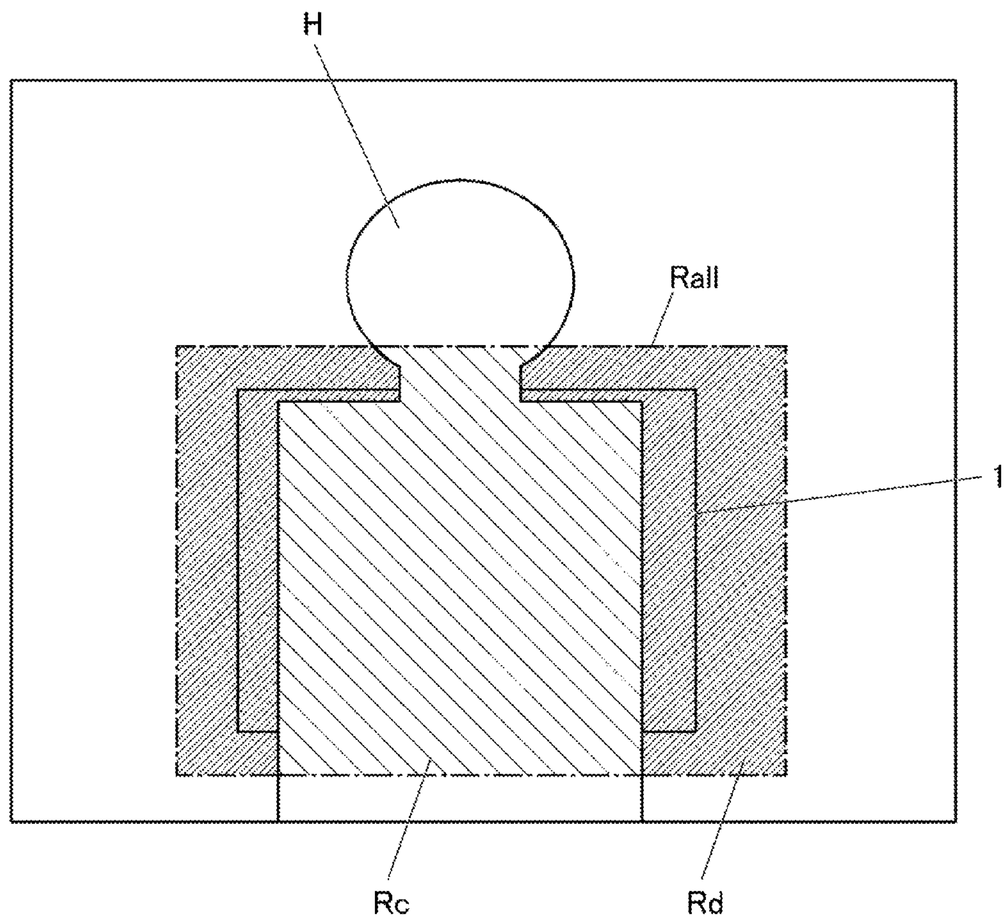


FIG. 23A

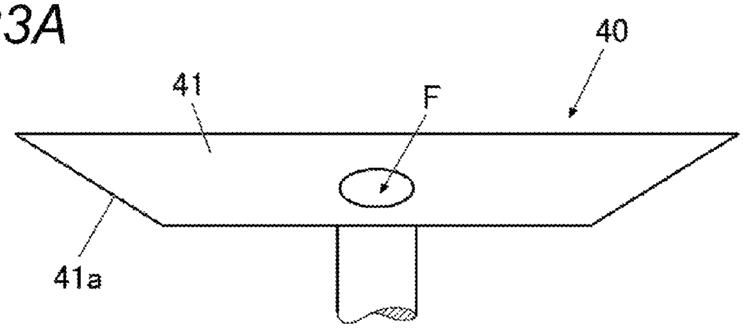


FIG. 23B

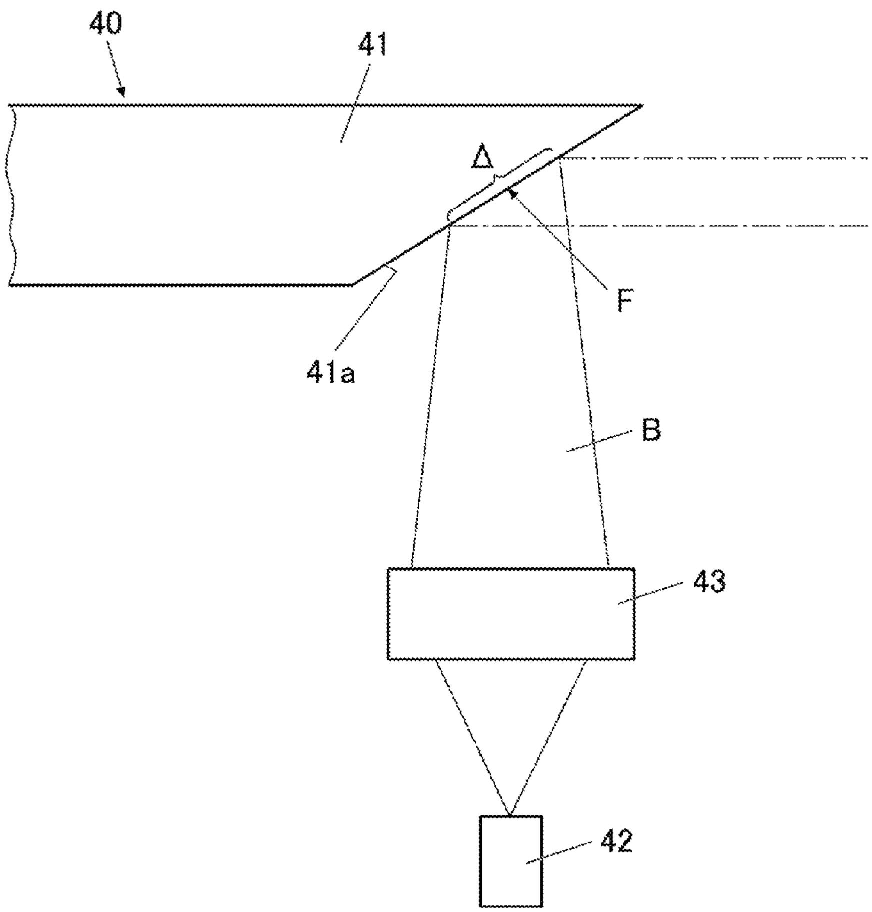


FIG. 24

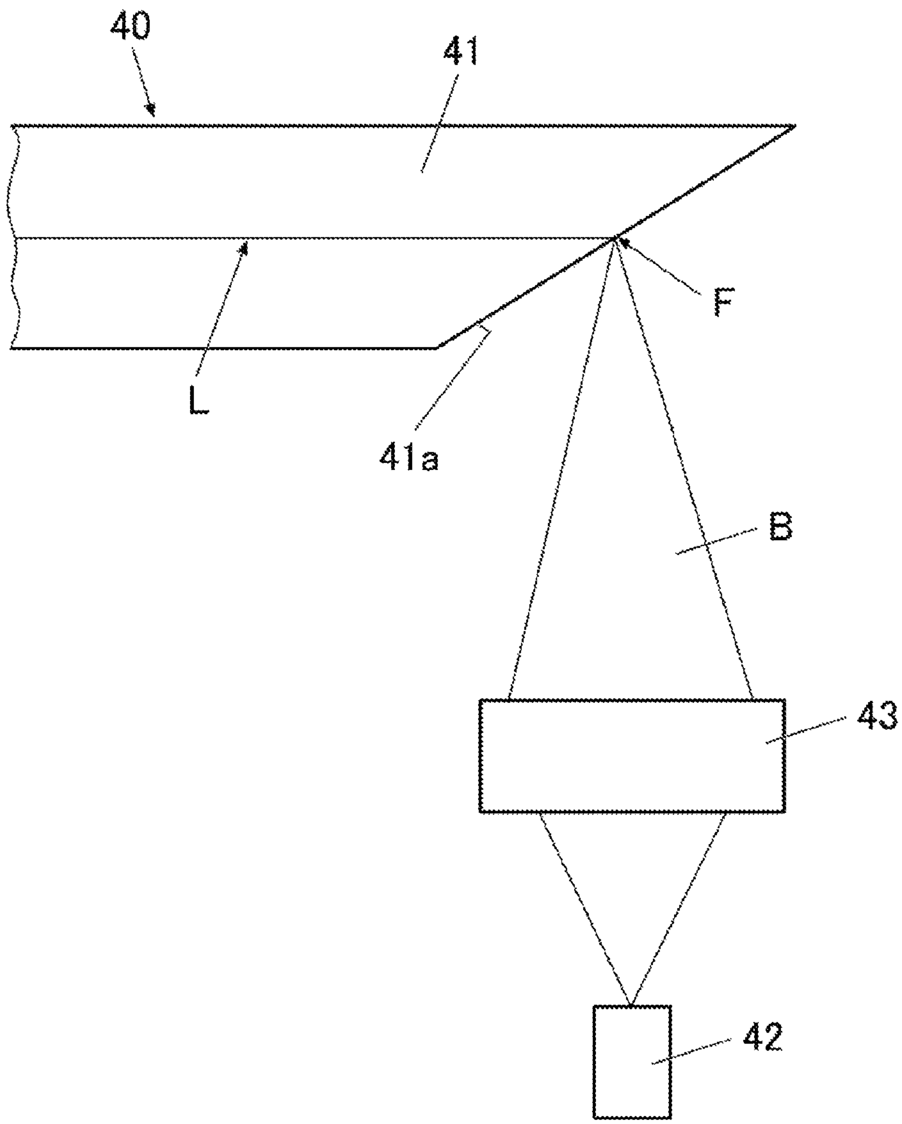


FIG. 25A

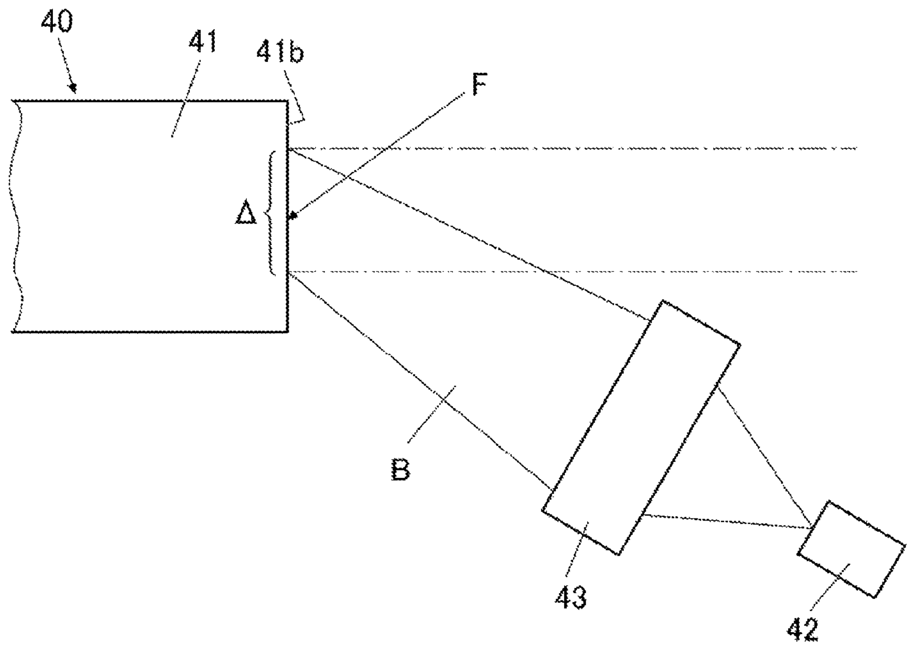


FIG. 25B

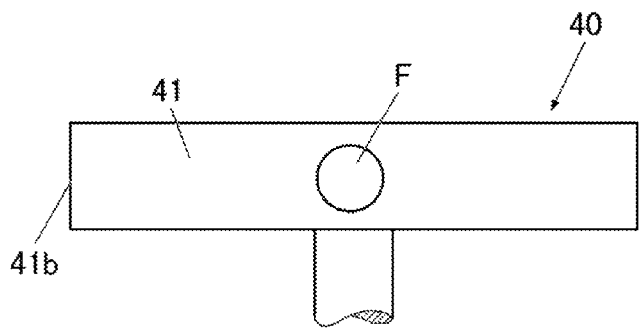
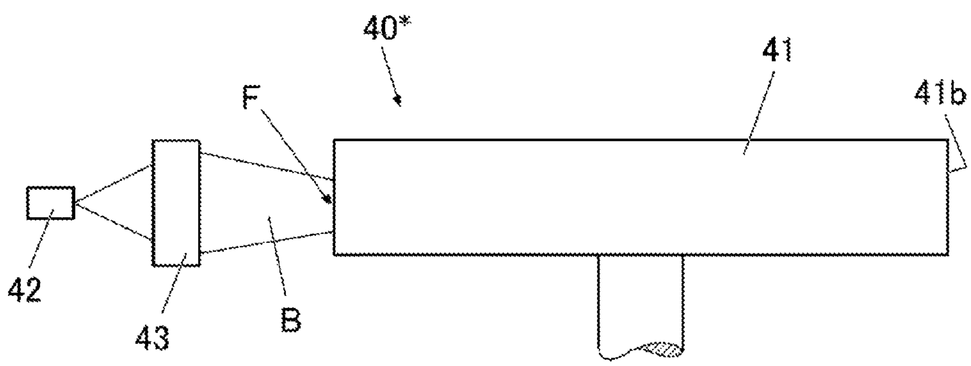


FIG. 26A



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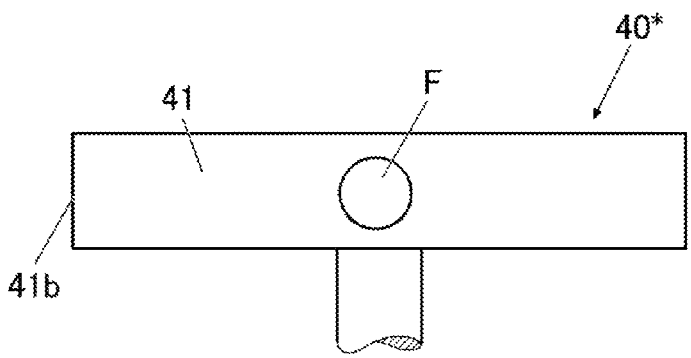

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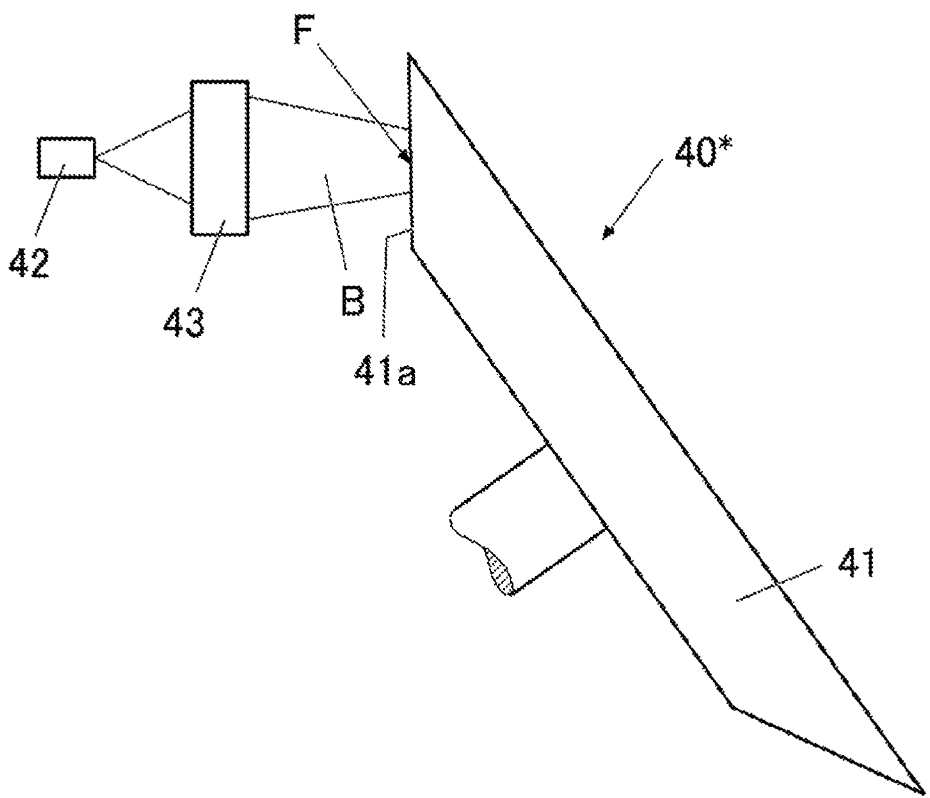
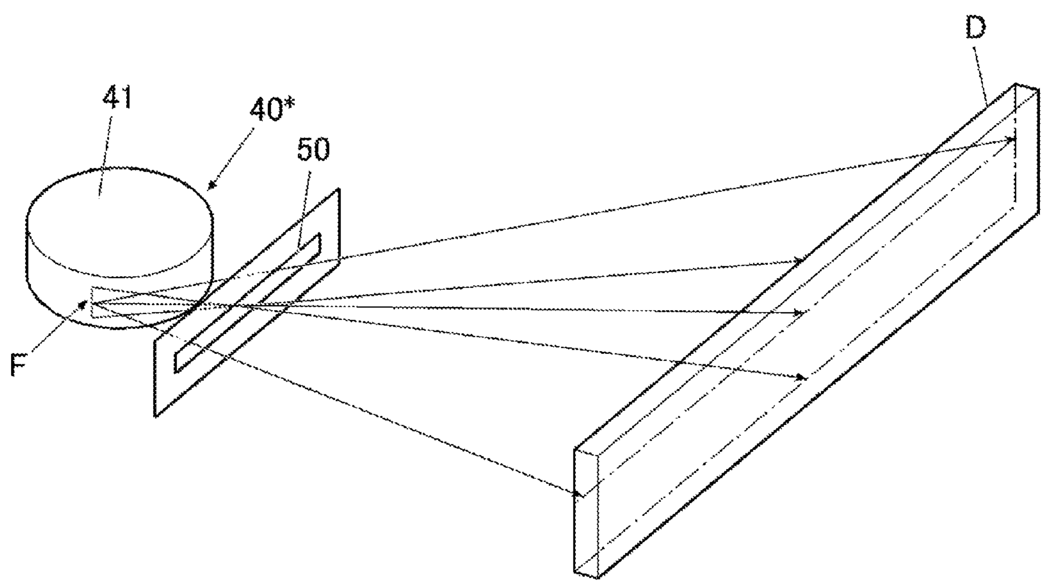


FIG. 28



IMAGING STAND

The entire disclosure of Japanese Patent Application No. 2014-042286 filed on Mar. 5, 2014 including description, claims, drawings, and abstract are incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to imaging stands, and more particularly, to an imaging stand to be used for imaging with a CR cassette or an FPD cassette installed therein.

2. Description of the Related Art

For the purpose of disease diagnoses and the like, radiation images such as X-ray images are widely used. Such radiation images for medical use are conventionally taken with the use of a screen-type film, but CR (Computed Radiography) devices using stimulable phosphor sheets have been developed to digitize radiation images. In recent years, radiographic imaging devices (flat panel detectors) that detect emitted radiation with radiation detecting elements and acquire the detected radiation as digital image data have been developed.

With a CR device, a CR cassette having a stimulable phosphor sheet in a cassette-type housing is conventionally installed in an imaging stand (also called a bucky imaging stand, a detector holder, or the like), and radiographic imaging is then performed in many cases. Radiographic imaging devices used to be developed as special-purpose devices formed integrally with supporting bases (see JP 3890163 B1 and JP 9-73144 A, for example). However, portable radiographic imaging devices that have radiation detecting elements and the like in housings and are designed to be portable have been developed and been put into practical use in recent years (see JP 2006-58124 A and JP 6-342099 A, for example). Such a portable radiographic imaging device will be hereinafter referred to simply as an FPD cassette. CR cassettes and FPD cassettes will be hereinafter collectively referred to as cassette-type detectors.

Meanwhile, various kinds of imaging stands each including a bucky into which a cassette-type detector is to be installed are being developed (see JP 2005-21233 A, for example). In many cases, an imaging stand is designed to be able to accommodate a cassette-type detector of 10×12 inches (quarter), 11×14 inches (large quarter), 14×14 inches (large square), 14×17 inches (half), 17×17 inches, or the like.

In a case where imaging is performed with a cassette-type detector of 14×17 inches installed in an imaging stand, for example, a cassette-type detector D is installed horizontally in an upper portion of the holder **102** in the bucky **101** of an imaging stand **100** as shown in FIG. **16**A, or a cassette-type detector D is installed horizontally in a center position in terms of the vertical direction in the holder **102** as shown in FIG. **16**B, or a cassette-type detector D is installed vertically in a center position in terms of the horizontal direction in the holder **102** as shown in FIG. **17**A, for example.

Hereinafter, a case where a cassette-type detector D is installed horizontally in an upper portion of the holder **102** as shown in FIG. **16**A will be referred to as "landscape top", a case where a cassette-type detector D is installed horizontally in a center position in terms of the vertical direction in the holder **102** as shown in FIG. **16**B will be referred to as "landscape center", and a case where a cassette-type detector D is installed vertically in a center position in terms of the horizontal direction in the holder **102** as shown in FIG. **17**A will be referred to as "portrait".

In a case where imaging is performed with a cassette-type detector D of 17×17 inches installed in an imaging stand, for example, the cassette-type detector D is installed in the holder **102** as shown in FIG. **17**B. The position of the upper edge of a cassette-type detector D of 14×17 inches placed in the "landscape top" position (see FIG. **16**A), the position of the upper edge of a cassette-type detector D of 14×17 inches placed in the "portrait" position (see FIG. **17**A), and the position of the upper edge of a cassette-type detector D of 17×17 inches (see FIG. **17**B) are made to be the same (at the same height from the floor surface or the like).

In a case where the orientation and the position of a cassette-type detector (an FPD cassette or a CR cassette) installed in a conventional imaging stand are changed, a complicated operation needs to be performed to pull the installed cassette-type detector D out of the holder **102** of the imaging stand **100**, adjust the position of the guide **103** that is to hold the cassette-type detector D when the cassette-type detector D is installed, and insert the cassette-type detector D back into the holder **102**.

As a result, not only the operability of the imaging stand **100** is degraded, but also the cassette-type detector D might be dropped when the cassette-type detector D is pulled out of or inserted back into the holder **102** as described above. If the cassette-type detector D is dropped, the cassette-type detector D might be broken, or the operator such as a radiological technologist might be injured as the cassette-type detector D falls onto a foot of the operator or crashes into the body of the operator, for example.

So as to improve such a situation and change the orientation and the like of the cassette-type detector D in the imaging stand **100** while avoiding ejection and insertion of the cassette-type detector D as much as possible, the holder **102** of the imaging stand **100** is provided on the back surface side of the imaging stand **100**, and a rotating mechanism that can rotate the holder **102** relative to the supporting member **104** supporting the holder **102** from the back surface side has been developed and is attached to the imaging stand **100**. In this structure, when the holder **102** holding a cassette-type detector D is rotated 90 degrees, the orientation and the position of the cassette-type detector D can be readily changed between the "landscape center" position (see FIG. **16**B) and the "portrait" position (see FIG. **17**A).

However, if the holder **102** is rotated 90 degrees while a cassette-type detector D is in the "landscape top" position (see FIG. **16**A), the orientation of the cassette-type detector D is changed to a vertical orientation, but the cassette-type detector D is not placed at the center in terms of the horizontal direction in the holder **102** and is shifted to the right or left, as can be clearly seen when FIG. **16**A is rotated 90 degrees clockwise or counterclockwise. Therefore, there is a need to provide not only the mechanism for rotating the holder **102** but also a mechanism for adjusting the position of the cassette-type detector D by moving the cassette-type detector D in the holder **102** or moving the holder **102**. With the addition of such a mechanism, not only the operability of the imaging stand **100** is degraded, but also higher costs are required. Furthermore, if the mechanism becomes complicated, high-precision adjustment of the orientation and the position of the cassette-type detector D in the imaging stand **100** might become difficult.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above problems, and an object thereof is to provide an imaging stand that can readily and accurately change the orientation and the position of the cassette-type detector held in a holder, without pulling out the cassette-type detector from the holder and pushing the cassette-type detector back into the holder, and can realize this feature at low costs.

To achieve the abovementioned object, according to an aspect, an imaging stand reflecting one aspect of the present invention comprises: a holder that holds an installed cassette-type detector; a supporting member that supports the holder from the back surface side; a circular gear secured to a shaft member protruding from the rotation center of the holder toward the supporting member on the back surface side, the holder being located in a different position from the position corresponding to the center of the radiation incidence surface of the cassette-type detector held in the holder; and a linear gear having concavities and convexities to be engaged with the teeth of the circular gear, the linear gear being attached to the supporting member, wherein, when the holder holding the cassette-type detector is rotated relative to the supporting member, the rotation center of the holder linearly moves relative to the supporting member as the holder rotates, and a change is caused in orientation and position of the cassette-type detector.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, advantages and features of the present invention will become more fully understood from the detailed description given hereinbelow and the appended drawings which are given by way of illustration only, and thus are not intended as a definition of the limits of the present invention, and wherein:

FIGS. **1**A and **1**B are diagrams showing the exterior of an imaging stand according to this embodiment, FIG. **1**A is a perspective view, and FIG. **1**B is a side view;

FIG. **2** is a diagram showing the structure and the like of the holder of the imaging stand in a situation where a panel of 14×17 inches is placed in a "landscape top" position;

FIG. **3**A is a diagram showing the trajectory of the center of the panel of 14×17 inches in a case where the holder is rotated;

FIG. **3**B is a diagram showing the trajectory of the point on the holder corresponding to the center of the panel of 14×17 inches in the case where the holder is rotated;

FIG. **4** is a diagram for explaining that, when the holder is rotated 90 degrees, the orientation and the position of the panel of 14×17 inches change from "landscape top" to "portrait", and the center of the panel of 14×17 inches moves;

FIG. **5** is a diagram for explaining that, when the holder is further rotated 90 degrees, the orientation and the position of the panel of 14×17 inches change from "portrait" to "landscape center", and the center of the panel of 14×17 inches does not move;

FIG. **6** is a diagram showing a situation where a panel of 17×17 inches is installed after the holder is rotated 270 degrees;

FIG. **7** is a diagram showing the positions of a panel of 17×17 inches and a panel of 14×17 inches, and the positions of the centers of the respective panels, after the holder is rotated 270 degrees;

FIG. **8** is a diagram showing the structures of a circular gear, the supporting member, and the like in this embodiment;

FIG. **9**A is a diagram showing the positions and the like of the circular gear and the center of a panel of 14×17 inches in a case where the rotation angle of the holder is 0 degrees;

FIG. **9**B is a diagram showing the positions and the like of the circular gear and the center of the panel of 14×17 inches after the holder is rotated 90 degrees;

FIG. **10**A is a diagram showing the positions and the like of the circular gear and the center of a panel of 14×17 inches after the holder is rotated 180 degrees;

FIG. **10**B is a diagram showing the positions and the like of the circular gear and the center of the panel of 14×17 inches after the holder is rotated 270 degrees;

FIG. **11** is a diagram for explaining that the center C of a cassette-type detector of 14×17 inches moves on a cycloid curve when the holder is rotated;

FIG. **12** is a diagram showing example structures of a slide plate, a stick-like member, and the like;

FIG. **13** is a diagram showing positional relationships among the stick-like member, a first locking claw, second locking claws, and others in cases where the rotation angle of the holder is 0 degrees and 90 degrees;

FIG. **14** is a side view of the holder **6** at the rotation angle of 0 degrees and others, seen from the left side in FIG. **13**;

FIG. **15** is a diagram showing positional relationships among the stick-like member, the first locking claw, the second locking claws, and others in cases where the rotation angle of the holder is 180 degrees and 270 degrees;

FIG. **16**A is a diagram showing a situation where a cassette-type detector of 14×17 inches is installed in a "landscape top" position in a conventional imaging stand;

FIG. **16**B is a diagram showing a situation where a cassette-type detector of 14×17 inches is installed in a "landscape center" position in a conventional imaging stand;

FIG. **17**A is a diagram showing a situation where a cassette-type detector of 14×17 inches is installed in a "portrait" position in a conventional imaging stand;

FIG. **17**B is a diagram showing a situation where a cassette-type detector of 17×17 inches is installed in a conventional imaging stand;

FIG. **18** is a diagram for explaining a method of calculating the distance SID between the focal point of the radiation source of an irradiation apparatus and the image receiving surface of a cassette-type detector by using a depth camera;

FIG. **19** is a diagram for explaining a vertical angle $\theta\mathbf{1}$ and a horizontal angle $\theta\mathbf{2}$ of a vector;

FIG. **20** is a diagram showing a region Ra of an imaged subject and a region Rb outside the imaged subject in a case where radiation is emitted and enters a cassette-type detector;

FIG. **21** is a diagram showing an example structure designed to measure the irradiation range of radiation with a radiation sensor;

FIG. **22** is a diagram showing a radiation range Rall defined in a captured image, a region Rc of the imaged subject, and a region Rd outside the imaged subject;

FIG. **23**A is a front view of the radiation source of a conventional irradiation apparatus, for explaining the structure and the focal point of the radiation source;

FIG. **23**B is a side view of the radiation source;

FIG. **24** is a diagram for explaining that, where the focal point is made too small, an electron beam is emitted only to a portion of a tilted surface of the rotating anode, and the portion is linearly damaged;

FIG. **25**A is a side view of a radiation source, for explaining that the apparent diameter of the focal point becomes larger in the vertical direction if an electron beam is emitted to an non-tilted side surface of the rotating anode;

FIG. **25**B is a front view of the radiation source;

FIG. 26A is a front view of a radiation source newly developed by the inventor;

FIG. 26B is a side view of the radiation source;

FIG. 27 is a front view of another example of a radiation source having a structure newly developed by the inventor; and

FIG. 28 is a diagram showing an example structure of a line-scanning irradiation apparatus formed with the radiation source shown in FIGS. 26A and 26B.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, an embodiment of an imaging stand of the present invention will be described with reference to the drawings. However, the scope of the invention is not limited to the illustrated examples.

FIGS. 1A and 1B are diagrams showing the exterior of an imaging stand according to this embodiment, FIG. 1A is a perspective view, and FIG. 1B is a side view. In this embodiment, the imaging stand **1** includes a bucky **2**, a stand **3** that can lift up and down the bucky **2** while supporting the bucky **2**, and a leg portion **4** for securing the stand **3** and the like to a floor surface or the like (not shown).

As shown in FIGS. 1A and 1B, in this embodiment, the imaging stand **1** is a so-called upright imaging stand, and imaging is performed while a patient as the subject stands (or is in an upright position) in front of the bucky **2**. Although not shown in the drawings, the present invention can also be applied to a so-called recumbent imaging stand for performing imaging while a patient is lying (or in a recumbent position) on a top panel or the like.

In this embodiment, a cassette-type detector D may also be a CR cassette or an FPD cassette. In the description below, a cassette-type detector D mounted on the imaging stand **1** will be referred to simply as a panel D. That is, each panel D mentioned in the description below is a CR cassette or an FPD cassette. Further, in the description below, the side of the stand **3** of the imaging stand **1** (or the back side in FIG. 1A) will be referred to as the back surface side.

The bucky **2** includes a main unit **5** that accommodates an installed panel D (see FIG. **2** and other drawings described later). The main unit **5** is formed in a box-like shape that has an opening **5***a* in one of the right and left side surface portions. A door portion **5***b* is formed in the opening **5***a*, and the door portion **5***b* can open and close by virtue of a hinge mechanism (not shown) provided on the back surface side of the main unit **5**. A panel D is installed and housed in the main unit **5** as described later, and the door portion **5***b* is closed, so that the opening **5***a* is blocked to enclose the panel D in the main unit **5**. A recess **5***c* for the subject such as a patient to rest his/her chin thereon when roentgenographic imaging is performed on the chest of the subject is formed in the upper surface portion of the housing of the main unit **5**.

As shown in FIG. **2**, the imaging stand **1** is designed so that a holder **6** that holds the installed panel D, a supporting member **7** that supports the holder **6** from the back surface side, and the like are housed in the main unit **5** of the bucky **2**. When a handle **8** attached to the supporting member **7** is pulled forward, the holder **6**, the supporting member **7**, and the like are pulled out of the main unit **5**, as shown in FIG. **2**. When the handle **8** is pushed back, the holder **6**, the supporting member **7**, and the like are housed in the main unit **5**, as shown in FIGS. **1**A and **1**B. FIG. **2** shows a case where the orientation and position of a panel D that is 14×17 inches in size and is installed in the holder **6** is "landscape top" (see FIG. **16**A). Reference numeral **6***x* in FIG. **2** will be described later.

In this embodiment, the holder **6** includes: a back surface plate **6***a* that supports the installed panel D from the back surface side; two restricting plates **6***b* that are arranged perpendicularly to the back surface plate **6***a*, and restrict movement of the panel D in the horizontal direction in FIG. **2**; a first locking claw **6***c* engaged with the lower edge portion of the panel D in FIG. **2**; and two second locking claws **6***d* that are provided on the opposite side from the first locking claw **6***c*, and are engaged with the upper edge portion of the installed panel D in FIG. **2**. The first locking claw **6***c* can slide up and down in FIG. **2**, and is pushed toward the second locking claws **6***d* by springs **6***e* or the like.

So as to prevent the penal D installed in the holder **6** from protruding forward in FIG. **2**, each of the first locking claw **6***c* and the second locking claws **6***d* is designed to have a rectangular shape minus a side in cross-section, and the first locking claw **6***c* and the second locking claws **6***d* are engaged with edge portions of the installed panel D on the side of a radiation incidence surface R. As shown in FIG. **2** and others, the first locking claw **6***c* can be designed as one elongated member. However, like the second locking claws **6***d*, the first locking claw **6***c* may be designed to be engaged with respective points of one edge portion of the panel D. Further, the second locking claws **6***d* have springs or the like (not shown), and are designed to move up and down in FIG. **2**. The second locking claws **6***d* are pushed toward the first locking claw **6***c* by springs or the like. The structure of the portion in which the second locking claws **6***d* of the holder **6** are provided will be described later.

When a panel D is installed into the holder **6**, the holder **6** is rotated 90 degrees in the counterclockwise direction in the situation of the holder **6** shown in FIG. **2** (the situation where no panel D is installed), and a panel D of 14×17 inches is then installed. Alternatively, the holder **6** is rotated 270 degrees in the counterclockwise direction in the situation shown in FIG. **2**, and a panel D of 17×17 inches is then installed.

When a panel D of 14×17 inches is installed into the holder **6** from the side of the handle **8** (see FIG. **2**) after the holder **6** is rotated 90 degrees in the counterclockwise direction in the situation shown in FIG. **2**, for example, the right edge of the panel D is brought into contact with the first locking claw **6***c* of the holder **6** located on the opposite side from the handle **8**, while vertical movement of the panel D is restricted by the restricting plates **6***b* located above and below of the holder **6** (to the right and the left of the holder **6** in FIG. **2**). The first locking claw **6***c* is then temporarily moved to the right (or toward the main unit **5** of the bucky **2**). In this situation, the left edge of the panel D is engaged with the second locking claws **6***d*. Accordingly, by virtue of the repulsive force of the springs **6***e* and other springs (not shown), the panel D is clamped between the first locking claw **6***c* and the second locking claws **6***d*. In this embodiment, when a panel D of 14×17 inches is installed into the holder **6** in the above manner, for example, the panel D is stably held by the holder **6**.

When a panel D of 17×17 inches is installed into the holder **6** from the side of the handle **8** (see FIG. **2**) after the holder **6** is rotated 270 degrees in the counterclockwise direction in the situation shown in FIG. **2**, for example, the right edge of the panel D is brought into contact with the second locking claws **6***d* of the holder **6** located on the opposite side from the handle **8**, while vertical movement of the panel D is restricted by the restricting plates **6***b* located above and below of the holder **6** (to the right and the left of the holder **6** in FIG. **2**), as will be described later with reference to FIG. **6**. The second locking claws **6*d*** are then temporarily moved to the right (or toward the main unit **5** of the bucky **2**). In this situation, the left edge of the panel D is engaged with the first locking claw **6*c***. Accordingly, by virtue of the repulsive force of the springs **6*e*** and other springs (not shown), the panel D is clamped between the first locking claw **6*c*** and the second locking claws **6*d***. In this embodiment, when a panel D of 17×17 inches is installed into the holder **6** in the above manner, for example, the panel D is also stably held by the holder **6**.

When a panel D is pulled out of the holder **6**, the panel D held by the holder **6** as described above is pressed against the locking claw(s) located to the right (or on the side of the main unit **5** of the bucky **2**), and the locking claw(s) (the first locking claw **6*c*** in the case of a panel D of 14×17 inches, and the second locking claws **6*d*** in the case of a panel D of 17×17 inches) is moved to the right. In this manner, the lock on the panel D by the locking claw(s) located on the left side of the panel D (or on the side of the handle **8**) is released. The panel D is then pulled toward the handle **8** in this situation, and is pulled out of the holder **6** with relative ease.

In a case where the installed panel D is an FPD cassette, a connector (not shown) is provided on a side surface of the panel D. However, where the first locking claw **6*c*** is designed as one elongated member as shown in FIG. **2**, an opening should be formed in the first locking claw **6*c*** at the location corresponding to the location of the connector of the FPD cassette when the panel D is installed into the holder **6**. With this arrangement, a connector **9** of the imaging stand **1** can be connected to the connector of the FPD cassette via the opening in a magnetic manner or the like.

A panel D is installed so that the radiation incidence surface R (or the surface from which radiation enters the panel D) is located on the front side in FIG. **2** (or the side on which the irradiation apparatus (not shown) that irradiates the panel D is located). C in FIG. **2** represents the center of the radiation incidence surface R of the panel D, but movement of the center C of the radiation incidence surface R of the panel D and the like will be described later.

In this embodiment, the imaging stand **1** is designed to be capable of rotating the holder **6** having a panel D installed therein relative to the supporting member **7** on the back surface side in a situation where the holder **6** and the supporting member **7** are pulled out of the main unit **5** as shown in FIG. **2**. However, the structure and the like of the imaging stand **1** will be described later. Further, in this embodiment, the holder **6** is rotated 90 degrees at a time relative to the supporting member **7** in this situation, so that the orientation and the position of a panel D of 14×17 inches, for example, can be changed from “landscape top” (see FIG. **16**A) to “portrait” (see FIG. **17**A) to “landscape center” (see FIG. **16**B). In the description below, this aspect of this embodiment is described.

In this embodiment, when the imaging stand **1** is actually used, a panel D of 14×17 inches is installed after the holder **6** not having any panel D installed therein is rotated 90 degrees in the counterclockwise direction in the situation shown in FIG. **2**, and a panel D of 17×17 inches is installed after the holder **6** is rotated 270 degrees in the counterclockwise direction in the situation shown in FIG. **2**. However, an explanation in accordance with this actual procedures will become complicated. Therefore, in the description below, the rotation angle in the situation shown in FIG. **2** is 0 degrees, and thereafter, the holder **6** is rotated 90 degrees at a time in the counterclockwise direction.

As will be described below, the orientation and the position of a panel D gradually change as the holder **6** is rotated 0 degrees, 90 degrees, 180 degrees, and 270 degrees in the counterclockwise direction. However, it is of course possible to rotate the holder **6** in the direction from 270 degrees to 180 degrees to 90 degrees to 0 degrees. As the holder **6** is rotated by each angle, the orientation and the position of a panel D can be changed to the orientation and the position corresponding to the angle.

Also, as can be seen from the description below, the present invention can be applied not only in cases where the panel D is 14×17 inches or 17×17 inches in size, but also in cases where the panel D is 11×14 inches or 14×14 inches in size. Thus, the present invention can be applied to panels D of various sizes.

[Principles of Change in the Orientation and the Position of a Panel D Only Through Rotation of the Holder]

As described above, in a case where the orientation and the position of a panel D installed and held in the holder **102** in the conventional imaging stand **100** are changed among “landscape top” (see FIG. **16**A), “portrait” (see FIG. **17**A), and “landscape center” (see FIG. **16**B), there is the need to prepare a mechanism that not only rotates the holder **102** by 90 degrees at a time relative to the supporting member **104**, but also moves the panel D in the holder **102** or moves the holder **102**.

In the present invention, on the other hand, changes in the orientation and the position of a panel D installed and held in the holder **6** can be realized only through rotation of the holder **6** relative to the supporting member **7**. In other words, according to the present invention, when a radiological technologist as the user rotates the holder **6** holding a panel D by 90 degrees at a time, the holder **6** automatically moves with the rotation, so that the orientation and the position of the panel D are adjusted to an appropriate orientation and an appropriate position. In the description below, the principles are described. The structure and the like for realizing the principles will be described later.

In the description below, the size of the panel D installed in the holder **6** is 14×17 inches. In this embodiment, through the above described rotating operation of the holder **6** relative to the supporting member **7**, not only a panel D of 14×17 inches but also a panel D of 17×17 inches can be appropriately positioned, and therefore, this aspect is also described below.

In a situation where a panel D of 14×17 inches is installed in the holder **6**, for example, and the rotation angle is 0 degrees as shown in FIG. **2**, the panel D is placed in a “landscape top” position. When the holder **6** is rotated 90 degrees in the counterclockwise direction in that situation, for example, the panel D is put into a “portrait” state (see FIG. **17**A). When the holder **6** is further rotated 90 degrees (180 degrees in total), the panel D is placed in a “landscape center” position. If a panel D of 17×17 inches is installed into the holder **6**, for example, and the holder **6** is rotated 270 degrees in the counterclockwise direction, the panel D of 17×17 inches is appropriately placed as shown in FIG. **6**, which will be described later.

First, attention is paid to the positions of the center C (see FIG. **2**) of the radiation incidence surface R of a panel D of 14×17 inches in the respective cases where the orientation and the position of the panel D installed in the holder **6** are adjusted to the “landscape top” position (see FIG. **16**A), where the holder **6** is rotated 90 degrees to place the panel D in the “portrait” position (see FIG. **17**A), and where the holder **6** is further rotated 90 degrees to place the panel D in the "landscape center" position (see FIG. **16**B). Hereinafter, the center C of the radiation incidence surface R of the panel D will be referred to simply as the center C of the panel D.

The position of the center C of the panel D in a case where the orientation and the position of the panel D of 14×17 inches installed in the holder **6** are "landscape top" (see FIG. **16**A) is the position α shown in FIG. **3**A, for example. FIG. **3**A and FIG. **3**B, which will be described later, are enlarged views showing movement of the center C (or the later described point C on the holder **6** corresponding to the center C) of a panel D when the panel D installed in the holder **6** is seen as shown in FIG. **2**.

When the panel D of 14×17 inches and the holder **6** are rotated 90 degrees in the counterclockwise direction (so that the upper side of the panel D shown in FIG. **2** becomes the left side), and is placed in the "portrait" position (see FIG. **17**A), the vertical panel D is not moved to the left but is located at the center in terms of the horizontal direction as shown in FIG. **4**. As described above, the position of the upper edge of the panel D of 14×17 inches set in the "landscape top" position is the same as the position (or the height from the floor surface or the like) of the upper edge of the panel D set in the "portrait" position (see FIG. **4**). Accordingly, the center C of the panel D placed in the "portrait" position is in the position β located immediately below the position α, as shown in FIG. **3**A.

In other words, so as to realize changes in the orientation and the position of the panel D installed and held in the holder **6** only through rotation of the holder **6** relative to the supporting member **7** as described above, the position of the center C of the panel D placed in the "portrait" position automatically moves (with the above rotation) to the position β immediately below the position α in FIG. **3**A, while the panel D in the "landscape top" position shown in FIG. **4** and the holder **6** (not shown in FIG. **4**) are rotated 90 degrees in the counterclockwise direction. In this case, the position of the center C of the panel D moves 1.5 inches (=(17−14)/2) from the position α to the position β immediately below the position α in FIG. **3**A, as can be seen from FIG. **4**.

When the panel D of 14×17 inches and the holder **6** are further rotated 90 degrees in the counterclockwise direction, and is placed in the "landscape center" position (see FIG. **16**B), the position β of the center C of the panel D in the "portrait" position is the same as the position γ of the center C of the panel D in the "landscape center" position, as shown in FIG. **3**A. That is, the center C of the panel D does not move, and the panel D rotates 90 degrees in the counterclockwise direction about the same positions β and γ, as shown in FIG. **5**

Therefore, in a case where the panels D to be installed into the holder **6** are only of the 14×17 inch type (or a 10×12 inch type or a 11×14 inch type, for example), the center C of the panel D moves as shown in FIG. **3**A every time the panel D of 14×17 inches and the holder **6** are rotated 90 degrees in the counterclockwise direction, so as to change the orientation and the position of the panel D from "landscape top" to "portrait" to "landscape center".

The panel D is rotated while being held in the holder **6**. Therefore, so as to move the center C of the panel D as shown in FIG. **3**A, the holder **6** is rotated relative to the supporting member **7** so that the point (hereinafter referred to as the point C) on the holder **6** corresponding to the center C of the panel D moves from C(α) to C(β) to C(γ) shown in FIG. **3**A as the holder **6** is rotated 90 degrees at a time in the counterclockwise direction, while the center C of the panel D is allowed to automatically move.

In this embodiment, not only a panel D of 14×17 inches but also a panel D of 17×17 inches can be appropriately positioned through rotating operation of the holder **6** relative to the supporting member **7** as described above. In this embodiment, when the holder **6** is rotated 270 degrees in the counterclockwise direction from a zero degrees state, and a panel D of 17×17 inches is installed into the holder **6** in that situation as described above, the panel D of 17×17 inches is placed in an appropriate position as shown in FIG. **6**. The "panel D of 17×17 inches being placed in an appropriate position" means that, when the holder **6** having a panel D of 17×17 inches installed therein is housed in the main unit **5** of the bucky **2** (see FIGS. **1**A and **1**B), the panel D of 17×17 inches is placed in an appropriate position in the main unit **5**, without shifting in the vertical direction or the horizontal direction.

In a case where a panel D of 17×17 inches is in an appropriate position as shown in FIG. **6**, the position of the center C* of the radiation incidence surface of the panel D of 17×17 inches (see FIG. **6**; the center C will be hereinafter referred to as the center C* of the panel D) should be the same as the position of the center C of a panel D of 14×17 inches in the above described case where the panel D of 14×17 inches is placed in the "portrait" orientation and position, or the above described center C(γ) (see FIG. **5** and others), as shown in FIG. **7**. This is because the length of the panel D of 14×17 inches placed in the "portrait" position is 17 inches in the vertical direction, which is the same as the length of the panel D of 17×17 inches. Therefore, the center of the panel D of 14×17 inches placed in the "portrait" position is in the same position as the center of the panel D of 17×17 inches in the vertical direction. Furthermore, as the panel D of 14×17 inches placed in the "portrait" position is located at the center in terms of the horizontal direction, the center of the panel D of 14×17 inches placed in the "portrait" position is also in the same position as the center of the panel D of 17×17 inches in the horizontal direction.

Meanwhile, where C(δ) represents the center C of the panel D of 14×17 inches in a case where the panel D of 14×17 inches, instead of the panel D of 17×17 inches, is installed in the holder **6** shown in FIG. **6** or the holder **6** rotated 270 degrees in the counterclockwise direction, as shown in FIG. **7**, the position of the center C(δ) of the panel D of 14×17 inches virtually installed in the holder **6** is 1.5 inches to the left of the position of the center C* of the panel D of 17×17 inches installed in the holder **6** in this situation where the holder **6** has been rotated 270 degrees in the counterclockwise direction as shown in FIGS. **6** and **7**.

That is, in a case where the center C of the panel D of 14×17 inches is regarded as a position on the holder **6**, when the holder **6** is rotated 0 degrees, 90 degrees, and then 180 degrees in the counterclockwise direction, the point C on the holder **6** moves from C(α) to C(β) to C(γ) as shown in FIG. **3**A. However, so as to put the holder **6** into a state where the holder **6** is further rotated 90 degrees in the counterclockwise direction after rotated 180 degrees, or a state where the holder **6** is rotated 270 degrees as shown in FIGS. **6** and **7** (a state where the panel D of 17×17 inches is placed in an appropriate position), the holder **6** should be moved while being rotated so that the point C moves to the position of the point C(δ) that is located 1.5 inches to the left of the point C(γ) as shown in FIG. **3**B.

[Structure and the Like Unique to the Present Invention]

Next, the structure and the like for moving the holder **6** of the imaging stand **1** in the above manner are described. The actions of the imaging stand **1** according to this embodiment are now described as well.

In this embodiment, the holder **6** has the rotation center in a position that is not the position of the point C on the holder **6** corresponding to the center C of the panel D held in the holder **6**. When the holder **6** holding the panel D is rotated 90 degrees at a time in the counterclockwise direction relative to the supporting member **7**, the rotation center of the holder **6** linearly moves relative to the supporting member **7** as the holder **6** rotates, and a change is caused in the orientation and the position of the panel D. This aspect is described below in detail.

As shown in FIG. **8**, a linear gear **7***a* having concavities and convexities in an engaging portion **7***b* on the upper side is formed in the supporting member **7**. The linear gear **7***a* is tilted at 45 degrees with respect to a horizontal surface.

A shaft member **6***f* is integrally formed with the holder **6** so that the shaft member **6***f* protrudes from the position of the rotation center **6***x* of the holder **6** (not shown) placed on the front side in FIG. **8** toward the supporting member **7** on the back surface side. The shaft member **6***f* rotates about the rotation center **6***x* as the holder **6** rotates in the above described manner. A circular gear **6***g* is secured to the shaft member **6***f*, and the teeth of the circular gear **6***g* are to be engaged with the concavities and convexities of the engaging portion **7***b* of the linear gear **7***a* (or the teeth of the linear gear **7***a*).

In this embodiment, as shown in FIG. **14**, which will be described later, the linear gear **7***a* is provided on the surface on the opposite side of the supporting member **7** from the side on which the holder **6** and the like are provided, and an elongated opening (not shown in FIG. **14**) formed at an upper portion of the linear gear **7***a* of the supporting member **7** and extends parallel to the engaging portion **7***b* of the linear gear **7***a*. The shaft member **6***f* formed to protrude from the holder **6** toward the supporting member **7** is inserted into this opening, and the circular gear **6***g* formed at the top edge of the shaft member **6***f* is engaged with the linear gear **7***a*. That is, when seen from the side of the holder **6**, the circular gear **6***g* and the linear gear **7***a* are engaged with each other on the back surface side of the supporting member **7**. As will be described later, when the circular gear **6***g* moves along the linear gear **7***a* (see FIGS. **9**A and **9**B, and FIGS. **10**A and **10**B, which will be described later), the shaft member **6***f* moves in the elongated opening (not shown). Therefore, the elongated opening is tilted 45 degrees with respect to a horizontal surface, so as to match the tilting of the engaging portion **7***b* of the linear gear **7***a*. Alternatively, the linear gear **7***a*, the circular gear **6***g*, and the like may be provided on the surface of the supporting member **7** on the side having the holder **6** and the like provided thereon.

In the above described structure in this embodiment, the holder **6** of the imaging stand **1** is moved while being rotated 90 degrees at a time in the counterclockwise direction as described above, so that the orientation and the position of a panel D of 14×17 inches can be changed from "landscape top" to "portrait" to "landscape center". Also, a panel D of 17×17 inches is inserted into the holder **6** after the holder **6** is rotated 270 degrees in the counterclockwise direction, so that the panel D of 17×17 inches can be placed in an appropriate position as shown in FIG. **6**.

This aspect is described below in detail. In the drawings to be described below, the circular gear **6***g* is represented by a circle, and the engaging portion **7***b* having the concavities and convexities of the linear gear **7***a* is represented by a straight line for simplification.

First, in a situation where the rotation angle of the holder **6** is 0 degrees, the circular gear **6***g* is located at an upper portion of the linear gear **7***a*, as shown in FIG. **9**A. In a perspective view of a panel D of 14×17 inches installed in the holder **6** like FIG. **2**, the circular gear **6***g* is located in such a position that the center C of the panel D (or the corresponding point C on the holder **6**, which is C(α) in FIG. **3**B and others) is located to the left of the rotation center **6***x* of the holder **6** or at the left edge of the circular gear **6***g*, as shown in FIG. **9**A.

When the holder **6** is rotated 90 degrees in the counterclockwise direction in this situation, the circular gear **6***g* also rotates 90 degrees in the counterclockwise direction, and moves obliquely downward along the engaging portion **7***b* of the linear gear **7***a*, as shown in FIG. **9**B. At this point, the holder **6** not shown in FIG. **9**B rotates 90 degrees in the counterclockwise direction about the rotation center **6***x* as the circular gear **6***g* rotates. Accordingly, the center C of the panel D of 14×17 inches installed in the holder **6** moves from the position on the left side of the rotation center **6***x* shown in FIG. **9**A to a position immediately below the rotation center **6***x*, as shown in FIG. **9**B.

As the holder **6** is rotated 90 degrees in the counterclockwise direction, the center C of the panel D of 14×17 inches moves from the position α to the position β located immediately below the position α, as shown in FIG. **9**B. As the holder **6** having the panel D of 14×17 inches installed therein is simply rotated 90 degrees in the counterclockwise direction in the above manner, the 1.5-inch movement of the center C from the position α to the position β shown in FIG. **3**B is realized, and the change in the orientation and the position of the panel D of 14×17 inches from "landscape top" to "portrait" shown in FIG. **4** is realized.

When the holder **6** having the panel D of 14×17 inches installed therein is further rotated 90 degrees in the counterclockwise direction, the circular gear **6***g* further rotates 90 degrees in the counterclockwise direction, and moves obliquely downward along the engaging portion **7***b* of the linear gear **7***a*, as shown in FIG. **10**A. As the holder **6** not shown in FIG. **10**A also rotates 90 degrees in the counterclockwise direction about the rotation center **6***x* with the rotation of the circular gear **6***g*, the center C of the panel D of 14×17 inches installed in the holder **6** moves from the position immediately below the rotation center **6***x* shown in FIG. **9**B to a position to the right of the rotation center **6***x*, as shown in FIG. **10**A.

As the holder **6** is further rotated 90 degrees in the counterclockwise direction, the center C of the panel D of 14×17 inches moves from the position β but eventually returns to the position β, as shown in FIG. **10**A (see C(γ) in FIG. **10**A). In the above manner, an operation can be performed so that the position β of the center C at the time when the holder **6** having the panel D of 14×17 inches installed herein is rotated 90 degrees in the counterclockwise direction is the same as the position γ of the center C at the time when the holder **6** is further rotated 90 degrees (180 degrees in total) in the counterclockwise direction as shown in FIG. **3**B, and the change in the orientation and the position of the panel D of 14×17 inches from "portrait" to "landscape center" shown in FIG. **5** is realized.

When the holder **6** is further rotated 90 degrees (270 degrees in total) in the counterclockwise direction in the situation where the holder **6** has already been rotated 180 degrees in total in the counterclockwise direction, the circular gear **6***g* further rotates 90 degrees in the counterclockwise direction, and moves obliquely downward along the engaging portion **7***b* of the linear gear **7***a*, as shown in FIG. **10**B. Accordingly, the point C corresponding to the center C of the panel D in the case where the panel D of 14×17 inches is installed in the holder **6** moves from the position on the right side of the rotation center **6***x* shown in FIG. **10**A to the position δ immediately above the rotation center **6***x*, as shown in FIG. **10**B.

That is, when the holder **6** already rotated 180 degrees in the counterclockwise direction is further rotated 90 degrees in the counterclockwise direction, the position of the center C of the panel D in the case where the panel D of 14×17 inches is installed in the holder **6** moves 1.5 inches leftward to the position δ from the position γ in FIG. **10**B.

When a panel D of 17×17 inches is installed into the holder **6** in this situation, the state shown in FIG. **6** is realized, and the position of the center C* of the panel D of 17×17 inches is 1.5 inches to the right of the position δ of the center C of the panel D in the case where the panel D of 14×17 inches is installed in the holder **6**, as shown in FIG. **7**. Accordingly, the position of the center C* of the panel D of 17×17 inches installed in the holder **6** is the same as the positions β and γ of the center C in the case where the panel D of 14×17 inches is placed in the "portrait" position and the "landscape center" position, and the panel D of 17×17 inches is eventually placed in the appropriate position shown in FIG. **6**.

As described above, as the panel D of 17×17 inches is installed after the holder **6** is rotated 270 degrees in the counterclockwise direction, the center C* of the panel D of 17×17 inches can be located in the center position (the same position as the positions β and γ of the center C in the case where the panel D of 14×17 inches is placed in the "portrait" position and the "landscape center" position) as shown in FIG. **6**, and the panel D of 17×17 can be placed in the appropriate position.

With the above described structure, the circular gear **6***g* is moved, while being rotated, along the engaging portion **7***b* on the upper side of the linear gear **7***a* tilted 45 degrees with respect to a horizontal surface in this embodiment. Accordingly, the circular gear **6***g* can be linearly moved with precision, and the circular gear **6***g* can be moved while being rotated, with the movement of the circular gear **6***g* being in accurate synchronization with the rotation (or the rotation angle).

Accordingly, as the holder **6** holding a panel D is rotated 90 degrees at a time in the counterclockwise direction as described above, the orientation and the position of a panel D of 14×17 inches can be changed among "landscape top", "portrait", and "landscape center". Also, as a panel D of 17×17 inches is installed into the holder **6** after the holder **6** is rotated 270 degrees in the counterclockwise direction, the positioning of the panel D of 17×17 inches can be performed with high precision. Furthermore, a radiological technologist or the like simply has to rotate the holder **6** holding a panel D. Accordingly, the panel D does not need to be pulled out of and be pushed back into the holder **6**, and the orientation and the position of the panel D can be very easily changed.

Also, in this embodiment, the above described operation of the holder **6** can be realized simply with the use of the circular gear **6***g*, the linear gear **7***a*, and the like. Accordingly, increases in the production cost of the imaging stand **1** can be prevented. Also, a radiological technologist or the like simply has to manually rotate the holder **6** holding a panel D, and there is no need to use an electric device such as a motor at least for rotating the holder **6**. The imaging stand **1** according to this embodiment can also realize the above described operation at low costs in that aspect.

The circular gear **6***g* has such a diameter as to realize the above described operation (particularly, the operation illustrated in FIG. **3**B). As can be seen from FIG. **10**B, for example, the diameter of the circular gear **6***g* is slightly shorter than the distance between the point C(α) and the point C(β), and, as can be calculated, the diameter of the circular gear **6***g* is approximately 1.35 inches in a case where the distance between the point C(α) and the point C(β) is 1.5 inches as described above.

The "1.5 inches" is calculated by dividing the difference between 17 inches and 14 inches, which are the length of the long side and the length of the short side of the panel D of 14×17 inches, by 2 ((the length of the long side−the length of the short side)/2). Therefore, where the imaging stand **1** is of a type that performs imaging with a panel D of 11×14 inches or 14×14 inches being installed, "(the length of the long side−the length of the short side)/2" is 1.5 inches, and the circular gear **6***g* is designed to have the same size as the circular gear **6***g* of this embodiment. Where the imaging stand **1** is of a type that performs imaging with a panel D of 10×12 inches being installed, "(the length of the long side−the length of the short side)/2" is 1 inch, and the circular gear **6***g* is designed to have a size that is two thirds of the size of the circular gear **6***g* of this embodiment.

[Effects]

As described above, in the imaging stand **1** according to this embodiment, the holder **6** has the rotation center **6***x* in a different position from the position C corresponding to the center C of the radiation incidence surface R of the panel D or a cassette-type detector D (an FPD cassette or a CR cassette) held in the holder **6**. When the holder **6** holding the cassette-type detector D is rotated relative to the supporting member **7**, the rotation center **6***x* of the holder **6** linearly moves relative to the supporting member **7** as the holder **6** rotates, and a change is caused in the orientation and the position of the cassette-type detector D.

With this structure, the orientation and the position of the cassette-type detector D held in the holder **6** can be appropriately and precisely changed among "landscape top", "portrait", and "landscape center". Accordingly, a change and the like can be caused in the orientation and the position of the cassette-type detector D simply by rotating the holder **6** holding the cassette-type detector D, without pulling the holder **6** out of the cassette-type detector D and pushing the holder **6** back into the cassette-type detector D. With the same rotating operation of the holder **6**, a cassette-type detector D of some other size (17×17 inches in the above described example) can also be positioned with high precision. Furthermore, where these actions are realized with the use of the circular gear **6***g* and the like, the above described high-precision operation can be realized at low costs.

Therefore, when the orientation and the position of a cassette-type detector D are changed or adjusted, there is no need to pull out the cassette-type detector D from the holder of the imaging stand, adjust the position of the guide, and insert the cassette-type detector D back into the holder as in a conventional imaging stand. Accordingly, the operability of the imaging stand **1** is higher. During the above described operation, a cassette-type detector D might be dropped and be broken, or a radiological technologist or the light might bump into a cassette-type detector D and be injured. With the imaging stand **1**, such accidents can be appropriately prevented.

In this embodiment, the holder **6** holding a cassette-type detector D is rotated in the counterclockwise direction.

However, the holder **6** may be rotated in the clockwise direction. In that case, the linear gear **7***a* is not tilted to the right as shown in FIG. **8** and other drawings, but needs to be tilted to the left, for example, though not shown in the drawings.

In view of general circular motion, rotating the holder **6** by 270 degrees in the counterclockwise direction from the position of the holder **6** shown in FIG. **2** is equal to rotating the holder **6** by 90 degrees in the clockwise direction from the position of the holder **6** shown in FIG. **2**, for example. As can be seen from the movement of the circular gear **6***g* relative to the linear gear **7***a* shown in FIGS. **9**A to **10**B, however, if the holder **6** is not rotated 270 degrees in the counterclockwise direction as described above but is rotated 90 degrees in the clockwise direction when a cassette-type detector D of 17×17 inches is positioned, for example, the circular gear **6***g* might move to the upper right and be disengaged from the linear gear **7***a*. Even if the circular gear **6***g* is not disengaged from the linear gear **7***a*, the center C* of the radiation incidence surface R of the cassette-type detector D of 17×17 inches is not placed in an appropriate position after the holder **6** is rotated 90 degrees in the clockwise direction. As a result, the cassette-type detector D of 17×17 inches cannot be placed in an appropriate position.

In a case where the above described operation (see FIG. **3**B) of the holder **6** is realized with the use of the circular gear **6***g*, the linear gear **7***a*, and the like as in the above described embodiment, when a cassette-type detector D of 17×17 inches is positioned, the holder **6** needs to be rotated not 90 degrees in the clockwise direction but 270 degrees in the counterclockwise direction (or the holder **6** needs to be rotated not 90 degrees in the counterclockwise direction but 270 degrees in the clockwise direction in a case where the linear gear **7***a* is tilted in the opposite direction and the holder **6** is rotated in the clockwise direction) before the cassette-type detector D of 17×17 inches is installed into the holder **6**.

In a case where the holder **6** is rotatably attached to the supporting member **7** of the imaging stand **1**, the holder **6** comes off on the front side in FIG. **2** if only the circular gear **6***g* and the linear gear **7***a* described above are used. Therefore, it goes without saying that a structure or the like is employed to prevent the holder **6** from coming off the supporting member **7** while allowing the above described rotating operation of the holder **6** relative to the supporting member **7**.

Further, in a case where a cycloid curve is defined as the "general term for a plane curve obtained as a trajectory of a fixed point on a circle when the circle rotates in accordance with certain rules" while a "cycloid curve" is defined in various ways, the point C moves from C(α) to C(β) to C(γ) to . . . (or in reverse order) on the trajectory of the fixed point C on the circle (or slightly outside the circle in reality) when the circle rotates in accordance with rules by which the circle (or the circular gear **6***g*) rotatively moves along a straight line (or the engaging portion **7***b* of the linear gear **7***a*), as can be seen from FIGS. **9**A and **9**B and FIGS. **10**A and **10**B. Therefore, the point C, which is the center C of a cassette-type detector D of 14×17 inches, moves on a cycloid curve.

In this embodiment, when the holder **6** is rotated relative to the supporting member **7**, the rotation center **6***x* of the holder **6** linearly moves relative to the supporting member **7** as the holder **6** rotates, as shown in FIGS. **9**A and **9**B and FIGS. **10**A and **10**B. In this structure, the center C of the cassette-type detector D of 14×17 inches installed in the holder **6** is moved on the cycloid curve shown in FIG. **11**. As the center C of the cassette-type detector D is moved on the cycloid curve, the orientation and the position of the cassette-type detector D can be appropriately changed.

It should be understood that the present invention is not limited to the above described embodiment, and various changes may be made to it without departing from the scope of the invention.

For example, in a case where the imaging stand **1** is a recumbent imaging stand, the imaging stand **1** may be designed so that a cassette-type detector D is not placed in the above described "landscape top" position (see FIG. **16**A), which may be applied in a case where the imaging stand **1** is an upright imaging stand. The "top" in the "landscape top" position in the case where the imaging stand **1** is a recumbent imaging stand means the side on which the head of the patient as the subject lying on the top panel of the recumbent imaging stand is located. That is, in recumbent imaging stands and some upright imaging stands, when a cassette-type detector D is placed in a landscape position, the cassette-type detector D is placed in the "portrait" position or the "landscape center" position, but might not be placed in the "landscape top" position where the cassette-type detector D is brought even closer to the head of the patient.

In a case where the present invention is applied to such an imaging stand **1**, the rotation angle of the holder **6** is not 0 degrees, but the holder **6** is designed to be rotated 90 to 180 degrees, or is designed to be rotated 90 to 270 degrees if a cassette-type detector D of 17×17 inches is also to be installed.

In a case where a cassette-type detector D of 14×17 inches is installed into the holder **6** in an actual structure of this embodiment, the cassette-type detector D of 14×17 inches is installed into the holder **6** after the holder **6** is rotated 90 degrees in the counterclockwise direction in the situation of the holder **6** shown in FIG. **2** (a situation where any cassette-type detector D is not installed). In this case, the cassette-type detector D of 14×17 inches is placed in the "portrait" orientation and position (see FIG. **17**A).

If this situation is regarded as the initial setting, the holder **6** is rotated 90 degrees in the counterclockwise direction relative to the supporting member **7**, so that the cassette-type detector D of 14×17 inches is placed in the "landscape center" orientation and position (see FIG. **16**B). When the holder **6** is rotated 90 degrees in the opposite direction, which is the clockwise direction, relative to the supporting member **7** in the above described initial setting, the cassette-type detector D of 14×17 inches is placed in the "landscape top" orientation and position (see FIG. **2** and FIG. **16**A).

When the holder **6** is rotated 180 degrees in the counterclockwise direction relative to the supporting member **7** in the above described initial setting, the holder **6** is placed in such a position that a cassette-type detector D of 17×17 inches can be installed. When a cassette-type detector D of 17×17 inches is installed into the holder **6** in that situation, the cassette-type detector D of 17×17 inches is placed in an appropriate position (see FIG. **6** and FIG. **17**B).

[Example Structure for Automatically Extending the Distance Between the First Locking Claw and the Second Locking Claws in Accordance with the Rotation Angle of the Holder]

In a case where a cassette-type detector D of 14×17 inches is installed into the holder **6** as shown in FIG. **2**, for example, the distance between the first locking claw **6***c* and the second locking claws **6***d* is 14 inches. In a case where a cassette-type detector D of 17×17 inches is installed, however, the above distance needs to be extended to 17 inches.

In the structure of the above described embodiment, the rotation angle of the holder **6** in a case where a cassette-type detector D of 14×17 inches is installed is 0 to 180 degrees, and a cassette-type detector D of 17×17 inches is installed in a situation where the holder **6** has been rotated 270 degrees in the counterclockwise direction. Therefore, the distance between the first locking claw **6***c* and the second locking claws **6***d* is 14 inches while the rotation angle of the holder **6** is 0 to 180 degrees, but the distance needs to be extended to 17 inches when the rotation angle becomes 270 degrees.

As a result of various studies that were made on a structure for automatically extending the distance between the first locking claw **6***c* and the second locking claws **6***d* from 14 inches to 17 inches at the same as the studies on the rotating operation for rotating the holder **6** as described above, the inventor discovered that such a structure can be realized by adding a relatively simple structure to the above described structure of this embodiment. In the description below, an example structure for realizing this is described.

In this case, the holder **6** is first designed as shown in FIG. **12**, for example. Specifically, the holder **6** is designed to include the back surface plate **6***a*, the restricting plates **6***b*, the first locking claw **6***c*, and the like, as in the above described embodiment. Although not shown in the drawing, the springs **6***e* are also attached to the first locking claw **6***c*, as in the holder **6** shown in FIG. **2**. At portions on the opposite side (the upper side in FIG. **12**) of the back surface plate **6***a* from the first locking claw **6***c*, slits **6***i* are formed to extend parallel to the restricting plates **6***b*, for example.

As shown in FIG. **12**, a slide plate **6***j* is provided separately from the back surface plate **6***a*. Convex portions **6***k* are formed in positions on the slide plate **6***j*, the positions corresponding to the slits **6***i* of the back surface plate **6***a*. The convex portions **6***k* of the slide plate **6***j* are then inserted into the slits **6***i* of the back surface plate **6***a* so that the convex portions **6***k* can move inside the slits **6***i* in the extending direction of the slits **6***i* (or the vertical direction in FIG. **12**). In this manner, the slide plate **6***j* is movably attached to the back surface plate **6***a*.

In the example shown in FIG. **12**, the slide plate **6***j* is attached to the back surface side of the back surface plate **6***a* or the back side in FIG. **12**, so that the convex portions **6***k* protrude forward in the drawing. In this case, the second locking claws **6***d* are attached to the slide plate **6***j*. Springs or the like (not shown) are also attached to the second locking claws **6***d*. The second locking claws **6***d* are attached to the slide plate **6***j* so as to be movable in the vertical direction in FIG. **12**, and are pushed toward the first locking claw **6***c* (or downward in FIG. **12**) by the springs or the like, as in the above described embodiment (see FIG. **2**).

A shaft portion **6***l* is provided in the center portion on the back surface side of the slide plate **6***j* in the horizontal direction in FIG. **12**, and one end of a stick-like member **6***m* is rotatably attached to the shaft portion **6***l*. As will be described later, the stick-like member **6***m* pushes and pulls the shaft portion **6***l*, so that the slide plate **6***j* moves in the extending direction of the slits **6***i* (or the vertical direction in FIG. **12**) relative to the back surface plate **6***a*. It should be noted that the stick-like member **6***m* neither expands nor contracts.

As shown in FIG. **13** (see the portion represented by the solid line in FIG. **13**), the other end of the stick-like member **6***m* is rotatably attached to a shaft portion **7***c* of the supporting member **7** (not shown in FIG. **13**, but shown in FIG. **14**, which will be described later). The shaft portion **7***c* is provided in a position near the above described point C(α) and the point C(β). More accurately, the shaft portion **7***c* is provided in a location on the supporting member **7**, the location being at a distance of 0.75 inches to the right of the middle position between the point C(α) and the point C(β) in the vertical direction, the point C(α) and the point C(β) being at a distance of 1.5 inches from each other in the vertical direction in FIG. **13**. As for the positional relationship with the above described rotation center **6***x* of the holder **6**, the shaft portion **7***c* is located in a position immediately below the rotation center **6***x* (equal to the center of the circular gear **6***g*) of the holder **6** shown in FIG. **9**A in the supporting member **7**, and is located in a position on a side (to the right) of the rotation center **6***x* of the holder **6** in a case where the holder **6** has been rotated 90 degrees in the counterclockwise direction as shown in FIG. **9**B.

In a case where the holder **6** is placed in a position where the rotation angle is 0 degrees, the stick-like member **6***m* has such a length relative to the back surface plate **6***a* that the slide plate **6***j* movable relative to the back surface plate **6***a* is located in a position where the distance between the first locking claw **6***c* and the second locking claws **6***d* becomes 14 inches.

So as to prevent interference between the above described rotating operation of the circular gear **6***g* relative to the linear gear **7***a* and the rotating operation of the stick-like member **6***m* with rotation of the holder **6** in this case, the circular gear **6***g* and the linear gear **7***a* can be provided on the back surface side of the supporting member **7**, and the stick-like member **6***m* and the shaft portion **7***c* can be provided on the surface side (the side on which the holder **6** is provided) of the supporting member **7**, as shown in FIG. **14**, for example. FIG. **14** is a side view of the holder **6** at the rotation angle of 0 degrees and others, seen from the left side in FIG. **13**.

When the holder **6** is rotated 90 degrees in the counterclockwise direction as described above in the situation shown in FIG. **13** or the situation where the rotation angle of the holder **6** is 0 degrees, the stick-like member **6***m* rotates about the shaft portion **7***c* on the supporting member **7**. As shown in FIG. **13** (see the portion indicated by the double-dot-and-dash lines in FIG. **13**), with the positional relationship between the back surface plate **6***a* and the slide plate **6***j* of the holder **6** being considered invariable, the distance between the shaft portion **6***l* on the slide plate **6***j* and the shaft portion **7***c* on the supporting member **7** in a situation where the holder **6** has been rotated 90 degrees in the counterclockwise direction to be located in the "portrait" position is calculated, and the calculated distance is exactly equal to the length of the stick-like member **6***m*. That is, even when the holder **6** is rotated 90 degrees in the counterclockwise direction, the shaft portion **6***l* of the slide plate **6***j* is not pushed by the stick-like member **6***m*, and the positional relationship between the slide plate **6***j* and the back surface plate **6***a* does not change. Therefore, the holder **6** is rotated 90 degrees in the counterclockwise direction, while the distance between the first locking claw **6***c* and the second locking claws **6***d* is maintained at 14 inches.

When the holder **6** is further rotated 90 degrees (180 degrees in total) in the counterclockwise direction in the above situation where the rotation angle of the holder **6** is 90 degrees, the stick-like member **6***m* rotates about the shaft portion **7***c* on the supporting member **7** as shown in FIG. **15** (see the portion indicated by the solid line in FIG. **15**). With the positional relationship between the back surface plate **6***a* and the slide plate **6***j* of the holder **6** being also considered invariable in this case, the distance between the shaft portion **6***l* on the slide plate **6***j* and the shaft portion **7***c* on the supporting member **7** in a situation where the holder **6** has been rotated 90 degrees in the counterclockwise direction to be located in the "landscape center" position is calculated, and the calculated distance is exactly equal to the length of the stick-like member **6***m*. That is, even when the holder **6** is further rotated 90 degrees in the counterclockwise direction in this case, the shaft portion **6***l* of the slide plate **6***j* is not pushed by the stick-like member **6***m*, either, and the positional relationship between the slide plate **6***j* and the back surface plate **6***a* does not change, either. Therefore, the holder **6** is rotated 90 degrees in the counterclockwise direction, while the distance between the first locking claw **6***c* and the second locking claws **6***d* is maintained at 14 inches.

In a case where a cassette-type detector D of 14×17 inches is installed into the holder **6** in the above described structure, as long as the rotation angle of the holder **6** is in the range of 0 to 180 degrees, the positional relationship between the back surface plate **6***a* of the holder **6** and the slide plate **6***j* supported by the stick-like member **6***m* does not change, and the distance between the first locking claw **6***c* and the second locking claws **6***d* is maintained precisely at 14 inches. Therefore, in a situation where the holder **6** is rotated within the rotation angle range (0 to 180 degrees), the cassette-type detector D of 14×17 inches is firmly interposed between the first locking claw **6***c* and the second locking claws **6***d* of the holder **6**, and is held in the holder **6**. Accordingly, it is possible to firmly maintain the state where the cassette-type detector D of 14×17 inches is held in the holder **6**.

In a case where the holder **6** is further rotated 90 degrees (270 degrees in total) (see the portion indicated by the double-dot-and-dash lines in FIG. **15**) in the above situation or a situation where the holder **6** has been rotated 180 degrees in the counterclockwise direction, if the positional relationship between the back surface plate **6***a* and the slide plate **6***j* of the holder **6** does not change as in the above cases, the shaft portion **6***l* on the slide plate **6***j* comes to the position denoted by **6***l** in FIG. **15**, but the distance between the point **6***l** and the shaft portion **7***c* on the supporting member **7** is apparently shorter than the length of the stick-like member **6***m*. Therefore, in this case, the shaft portion **6***l* of the slide plate **6***j* is pushed to the right in the drawing by the stick-like member **6***m*, and the slide plate **6***j* moves (slides) to the right in the drawing relative to the back surface plate **6***a*.

When the movement distance of the slide plate **6***j* relative to the back surface plate **6***a* is calculated from the length of the stick-like member **6***m* and the like, the calculated distance is 3 inches, and the distance between the first locking claw **6***c* and the second locking claws **6***d*, which was 14 inches in the above case, is extended to 17 inches automatically (or simply by rotating the holder **6**). Accordingly, a cassette-type detector D of 17×17 inches can be precisely installed into the holder **6** in this situation or the situation where the holder **6** has been rotated 270 degrees in total in the counterclockwise direction, and the holder **6** can firmly maintain the cassette-type detector D of 17×17 inches in this state.

It should be noted that the holder **6** is not limited to the structure including the back surface plate **6***a*, the slide plate **6***j*, and the like shown in FIG. **12**, but may have any kind of structure, as long as the distance between the first locking claw **6***c* and the second locking claws **6***d* can be extended with the stick-like member **6***m* in accordance with the rotating operation of the holder **6** as described above.

[Automatic Setting and the Like of a Field of Radiation to be Emitted to a Cassette-Type Detector]

In a case where imaging is performed by emitting radiation from an irradiation apparatus to a cassette-type detector D installed in the above described imaging stand **1** via a subject, the radiation field is normally narrowed by a collimator so that healthy body parts other than the affected area or the involved area of the patient as the subject are not exposed to radiation, and the dose of radiation to which the patient is exposed does not exceed the necessary amount.

Conventionally, the region exposed to radiation from an irradiation apparatus is also irradiated with visible light from a halogen lamp or the like. While looking at the irradiation, a radiological technologist or the like adjusts the position and the irradiation direction of the radiation emitted toward the subject by manually adjusting the position and the orientation of the irradiation apparatus, or narrows the radiation field by operating the collimator or the like, so that the radiation is emitted to an appropriate region including the affected area or the like of the patient. However, if this operation is automatically performed by the irradiation apparatus, the user-friendliness of the irradiation apparatus can increase.

In view of this, U.S. Pat. No. 7,806,591, for example, discloses a technology for automatically detecting the SID (Source Image receptor Distance) or the distance between the focal point of the radiation source (source) of the irradiation apparatus and the image receiving surface of a cassette-type detector D (image receptor) by providing a reflective member in the cassette-type detector D and sensing the distance to the reflective member. The image receiving surface of the cassette-type detector D may be the above described radiation incidence surface R (see FIG. **2** and others) of the cassette-type detector D, but more accurately, is the surface on which radiation detecting elements are two-dimensionally arranged on a sensor substrate in the cassette-type detector D.

However, where the cassette-type detector D is installed in the imaging stand **1**, the reflective member provided in the cassette-type detector D cannot be detected from the irradiation apparatus by the above method.

U.S. Pat. No. 7,545,914 discloses a technology for sensing the position of each apparatus and the position of a patient by providing a camera or the like in the imaging room where the irradiation apparatus, the imaging stand **1**, and the like are set, and imaging the inside of the imaging room, for example. In this case, however, if there is a person such as a radiological technologist or an attendant in addition to the patient, or if there is an obstacle, the position of each apparatus and the position of the patient might not be detected. Also, complicated image processing becomes necessary, and it is difficult to estimate the optical axis of radiation emitted from the irradiation apparatus. As a result, the position of the irradiation apparatus to be used is limited.

In view of this, the inventor has suggested a technology for detecting the rotating direction of the collimator and the optical axis direction or the like of emitted radiation by adding a camera to the collimator of the irradiation apparatus, and analyzing images captured by the camera (see JP 2011-92612 A and others). As a result of further studies on such technologies, the inventor succeeded in developing a technology for automatically and appropriately setting a radiation field with a collimator by detecting the position of the radiation source of the irradiation apparatus, the rotating direction of the collimator, the optical axis direction of emitted radiation, and the like. In the description below, this technology is described.

As shown in FIG. **18**, in an irradiation apparatus **20**, a collimator **21** that has a diaphragm or the like provided therein and narrows the field of radiation to be emitted from the irradiation apparatus **20** is attached to a cylindrical unit **22** in which the radiation source (not shown, but see the radiation source **40** shown in FIGS. **23**A and **23**B, which will be described later, for example) of the irradiation apparatus **20** is housed. Although not shown in the drawing, the collimator **21** is designed to be able to automatically and accurately change the degree of opening of the aperture of the diaphragm (the subject or the like is exposed only to radiation that has passed through this aperture from the irradiation apparatus **20**) by a known technique.

An imaging measurement unit **23** such as a depth camera that can capture an image and measure the distance to the imaged subject is attached to the collimator **21**. Although the imaging measurement unit **23** is described below as the depth camera **23**, the imaging measurement unit **23** is not necessarily formed with a depth camera, and is not particularly limited to a specific structure, as long as the imaging measurement unit **23** can capture an image and measure the distance to the imaged subject.

The collimator **21** and the depth camera **23** are secured to the cylindrical unit **22** and the collimator **21** of the irradiation apparatus **20**, respectively. The positional relationship between the focal point F of the radiation source of the irradiation apparatus **20** and the imaging center O of the depth camera **23** is invariable, and the distance r**0** between the focal point F and the imaging center O, and the offset vector v**0** from the imaging center O to the focal point F of the radiation source of the irradiation apparatus **20** are known in advance.

Markers M**1**, M**2**, and M**3** are formed in positions that do not have any patient or any other apparatus interposed between the irradiation apparatus **20** and the positions, and are not affected by the use of an apparatus or the like. Examples of such positions include upper portions of a wall surface of the imaging room where the irradiation apparatus **20** is set, or upper end portions of the stand **3** (see FIGS. **1**A and **1**B) of the imaging stand **1**. The coordinates (or the latitudes, the longitudes, and the heights from the floor surface (or the altitudes)) of the respective centers of the markers M**1** to M**3** in the real space are measured beforehand and are known. Shapes, colors, and the like of the markers M**1** to M**3** are determined as appropriate.

In the above described structure, the irradiation apparatus **20** automatically detects the position of the focal point F of the radiation source, the irradiation direction of radiation, the distance to the cassette-type detector D installed in the imaging stand **1** (or the above described SID; hereinafter, this distance will be referred to as the distance SID), and the like, and automatically and accurately set a field of radiation. Referring now to FIG. **18**, this technique is described below. The description below is based on the assumption that the irradiation apparatus **20** performs all processes including the process of calculating the distance SID. However, a structure (or a radiological imaging system including the irradiation apparatus **20** and a processing apparatus) may be formed so as to transmit data and the like from the irradiation apparatus **20** or the like to an external processing apparatus (not shown), and perform the process of calculating the distance SID with the processing apparatus.

First, the markers M**1** to M**3** are imaged by the depth camera **23**. In a case where the markers M**1** to M**3** are colored, the depth camera **23** captures a color image of the markers M**1** to M**3**, and detects the positions of the markers M**1** to M**3** in the image. The distances r**1** to r**3** to the respective centers of the markers M**1** to M**3** are measured and acquired with the depth camera **23**. As the coordinates of the respective centers of the markers M**1** to M**3** in the real space are known as described above, the coordinates of the imaging center O of the depth camera **23** are determined from the distances r**1** to r**3** and the coordinates of the respective centers of the markers M**1** to M**3** in the real space.

To calculate the above described distance SID, a process of determining the coordinates of the focal point F of the radiation source of the irradiation apparatus **20** in the real space is performed. In this case, the coordinates of the focal point F of the radiation source of the irradiation apparatus **20** in the real space cannot be determined, unless not only the coordinates of the imaging center O of the depth camera **23** determined in the above described manner and the above described offset vector v**0**, but also the orientation of the depth camera **23** (or a vertical angle θ**1** and a horizontal angle θ**2** of the camera direction v**1** described later), and the rotation angle (or the overall rotation angle θ**3** described later) of the entire irradiation apparatus **20** about the irradiation direction of radiation (or the X-ray direction v**2** described later) are known.

In view of this, the orientation of the depth camera **23** is first determined. As the one plane that passes through three point can be determined, the virtual plane S**1** that passes through the markers M**1** to M**3** are set in the real space. Meanwhile, the pixel positions of the markers M**1** to M**3** in the image captured by the depth camera **23** are determined, and the positional relationship among the respective pixel positions, and the positional relationship between each pixel position and the image center are determined. The positional relationships in the image are then applied to the virtual plane S**1** that is set in the real space as described above, and the coordinates of a point P**1** in the real space are determined. The point P**1** is formed by projecting the image center onto the virtual plane S**1**.

The direction from the imaging center O of the depth camera **23** toward the point P**1** (or the direction of the vector v**1** from the imaging center O toward the point P**1**) will be hereinafter referred to as the camera direction v**1**. The depth camera **23** is attached to the collimator **21** in advance, so that the camera direction v**1** becomes parallel to the irradiation direction v**2** (hereinafter referred to as the X-ray direction v**2**) of radiation from the irradiation apparatus **20**.

As shown in FIG. **19**, the angles θ**1** and θ**2** of the respective vectors formed by projecting a vector v onto the reference vertical plane (the y-z plane in FIG. **19**) and the reference horizontal plane (the x-y plane in FIG. **19**) with respect to the vertical axis (the z-axis in FIG. **19**) and the reference horizontal axis (the x-axis in FIG. **19**) are referred to as the vertical angle θ**1** and the horizontal angle θ**2** of the vector v, respectively. Also, as shown in FIG. **18**, the angle θ**3** of the entire irradiation apparatus **20** rotated about the reference axis in an overall rotation plane Sr is referred to as the overall rotation angle θ**3**.

After the coordinates of the point P**1** in the real space are determined as described above, the vector v**1** (see FIG. **18**) connecting the imaging center O and the point P**1** or the camera direction v**1** is determined, as the coordinates of the imaging center O of the depth camera **23** in the real space are already known. Accordingly, the vertical angle θ**1** and the horizontal angle θ**2** of the camera direction v**1** can be determined as shown in FIG. **19**.

With the camera direction v**1** being the normal line, a virtual plane S**2** that passes through one marker M (the marker M**3** in the case shown in FIG. **18**) among the three markers M**1** to M**3** is set in the real space. The coordinates of the point P**2** formed by projecting the image center onto the plane S**2** are then determined in the real space. The overall rotation angle θ**3** is then calculated from the coordinates of the point P**2** in the real space and the coordinates of the marker M**3** in the real space. In this manner, it is possible to recognize that the entire irradiation apparatus **20** has been rotated by the overall rotation angle θ**3** about the reference axis in the overall rotation plane Sr.

The above described offset vector v**0** (see FIG. **18**) is defined as the vector (va, vb, vc) from the imaging center θ of the depth camera **23** toward the focal point F of the radiation source of the irradiation apparatus **20** in a case where the vertical angle θ**1** and the horizontal angle θ**2** of the camera direction v**1**, and the overall rotation angle θ**3** of the entire irradiation apparatus **20** are all 0 degrees. Therefore, the actual orientation of the offset vector v**0** is calculated based on the actual vertical angle θ**1**, horizontal angle θ**2**, and overall rotation angle θ**3**, which have been determined in the above described manner. That is, the respective components va*, vb*, and vc* of the actual offset vector v**0** are determined from the respective components va, vb, and vc of the offset vector v**0**=(va, vb, vc), and the above described vertical angle θ**1**, horizontal angle θ**2**, and overall rotation angle θ**3**.

The coordinates of the focal point F of the radiation source of the irradiation apparatus **20** can be calculated based on the determined actual offset vector v**0** and the already determined coordinates of the imaging center O of the depth camera **23** in the real space. In the above manner, the coordinates of the focal point F of the radiation source of the irradiation apparatus **20** in the real space are first calculated.

In a case where the offset vector v**0** is defined as a unit vector (the length being 1) of the vector from the imaging center O of the depth camera **23** toward the focal point F of the radiation source of the irradiation apparatus **20**, the vector calculated by multiplying the offset vector v**0** by the distance r**0** between the imaging center O of the depth camera **23** and the focal point F of the radiation source of the irradiation apparatus **20** is of course used in the above described calculation.

Meanwhile, in the imaging stand **1** (see FIGS. **1**A and **1**B, and others), the cassette-type detector D installed in the bucky **2** can move up and down along the stand **3** of the imaging stand **1**, as described above. In that case, the cassette-type detector D moves up and down in a virtual plane S_D (see FIG. **18**) in the real space. Hereinafter, the virtual plane S_D will be referred to as the operation plane S_D of the cassette-type detector D. The above described distance SID is the distance from the focal point F of the radiation source of the irradiation apparatus **20** having its coordinates in the real space determined in the above described manner, to the operation plane S_D of the cassette-type detector D.

The X-ray direction v**2** or the irradiation direction v**2** of radiation from the focal point F of the radiation source of the irradiation apparatus **20** is parallel to the camera direction v**1** as described above, and the camera direction v**1** has already been calculated as the vector that connects the imaging center O of the depth camera **23** and the point P**1** in the virtual plane S**1** as described above. Therefore, the vector of the X-ray direction v**2** (the components of the vector are the same as the respective components of the camera direction v**1**) is extended from the focal point F of the radiation source of the irradiation apparatus **20** having its coordinates in the real space determined in the above described manner, and the intersection P_D with the operation plane S_D of the cassette-type detector D is determined. The distance between the focal point F of the radiation source of the irradiation apparatus **20** and the point P_D in the operation plane S_D of the cassette-type detector D determined in the above described manner is the distance SID to be determined.

In the above described manner, the distance SID from the focal point F of the radiation source of the irradiation apparatus **20** to the image receiving surface of the cassette-type detector D can be automatically and accurately calculated by the irradiation apparatus **20** or an external processing apparatus that has obtained data from the irradiation apparatus **20**.

Once the above distance SID is calculated, radiation is accurately emitted from the irradiation apparatus **20** to the cassette-type detector D in the above described operation plane S_D. Also, it is possible to determine to what extent radiation should be emitted from the irradiation apparatus **20** in the horizontal direction and the vertical direction so as to prevent radiation exposure outside the cassette-type detector D. That is, the field of radiation to be emitted can be determined. In this case, the information about the size, the orientation, and the position (such as the above described "landscape top", "portrait", or "landscape center" position) of the cassette-type detector D installed in the imaging stand **1** is necessary. Therefore, this information is input to the irradiation apparatus **20** by a radiological technologist or from an external device such as a console.

In this manner, the irradiation apparatus **20** calculates the field of radiation to be emitted in the horizontal direction and the vertical direction based on the information, so that the degree of opening of the aperture of the diaphragm in the collimator **21** can be adjusted to automatically and accurately set the radiation field.

Thereafter, the information about the height (or the altitude as in the description below) of the cassette-type detector D in the imaging stand **1** from the floor surface is input to the irradiation apparatus **20** by a radiological technologist or the like, the height of the bucky **2** of the imaging stand **1** from the floor surface is determined from an image analysis conducted on an image captured by the depth camera **23** or the like, or the height of the cassette-type detector D from the floor surface is determined by providing a marker on the bucky **2** separately from the above described markers M**1** to M**3** and determining the height of the bucky **2** of the imaging stand **1** from an image of the marker imaged by the depth camera **23** in the same manner as above.

The irradiation apparatus **20** changes the X-ray direction v**2** as the irradiation direction of radiation by changing the above described vertical angle θ**1** and horizontal angle θ**2**, or adjusts the overall rotation angle θ**3** by rotating the cylindrical unit **22** and the irradiation apparatus **20**, where necessary. In this manner, the radiation emitted from the focal point F of the radiation source precisely reaches the cassette-type detector D existing at the above determined height from the floor surface.

As the irradiation apparatus **20** or the radiological imaging system including the irradiation apparatus **20** and a processing apparatus has the above described structure, the irradiation apparatus **20** or the processing apparatus that has obtained data from the irradiation apparatus **20** automatically and accurately calculates the distance SID from the focal point F of the radiation source of the irradiation apparatus **20** to the image receiving surface of the cassette-type detector D. Based on the distance SID, the irradiation apparatus **20** emits radiation to the cassette-type detector D, and automatically and appropriately sets a radiation field so that radiation is not emitted to any region outside the cassette-type detector D. Accordingly, the irradiation apparatus **20** can have higher user-friendliness.

So as to set a radiation field with even higher precision, and expose only the necessary area including the affected area or the involved area of the patient as the subject to radiation while preventing the healthy body parts from being exposed to radiation, a structure for setting a narrower radiation field with high precision by inputting necessary information to the irradiation apparatus **20**, for example, may be added to the above described technology.

In this case, the patient as the subject is invariably positioned between the focal point F of the radiation source of the irradiation apparatus **20** and the cassette-type detector D at a time of imaging. Accordingly, in a case where an object is detected at a location closer to the irradiation apparatus **20** than to the cassette-type detector D (or at a shorter distance than the distance SID) as a result of distance measurement with the depth camera **23** at the time of imaging, the object can be recognized as the subject (or the patient). At this point, the patient as the subject invariably exists near the imaging stand **1**. Since the operation plane S_D (see FIG. **18**) of the cassette-type detector D is already known as described above, the space in which the subject exists can be assumed to be near the operation plane S_D of the cassette-type detector D or near the imaging stand **1** as detected from the operation plane S_D and is on the side of the irradiation apparatus **20**. The space can be readily determined, because whether the space is located near the cassette-type detector D or the imaging stand **1** on the side of the irradiation apparatus **20** can be determined by the depth camera **23**. At a time of imaging, radiation is invariably emitted toward the subject. Accordingly, by using the above information, the irradiation apparatus **20** can automatically and appropriately set the radiation field so that radiation will be emitted only to the smallest possible area to image the subject.

If the irradiation apparatus **20** obtains information indicating the exact location of the affected area or the involved area in the body of the patient, the irradiation apparatus **20** can further narrow the radiation field so that radiation will be emitted only to the necessary area including the affected area or the like.

Alternatively, the irradiation apparatus **20** can also be designed to set the radiation field so that radiation will be emitted only to the cassette-type detector D as described above, and then perform an operation to narrow the radiation field so that a radiological technologist or the like can manually apply radiation only to the necessary area including the affected area or the involved area of the patient as the subject.

In the above described example, a cassette-type detector D is installed in the so-called upright imaging stand **1** shown in FIGS. **1**A and **1**B and others, and the cassette-type detector D moves up and down with vertical movement of the bucky **2**, with the image receiving surface of the cassette-type detector D facing substantially in the horizontal direction. However, there are cases where a cassette-type detector D moves up and down, with the image receiving surface of the cassette-type detector D facing upward, as in a case where a cassette-type detector D is installed in a so-called recumbent imaging stand.

In such a case, a marker that is separate from the above described markers M**1** to M**3** is provided on a portion that moves up and down with the cassette-type detector D and can be imaged by the depth camera **23** of the irradiation apparatus **20**, such as the bucky having the cassette-type detector D installed therein or the top panel of the recumbent imaging stand (or the panel on which the subject is to lie down). The height of the bucky or the top panel of the recumbent imaging stand from the floor surface is then determined from an image of the marker imaged by the depth camera **23** in the same manner as above. After that, the height of the cassette-type detector D from the floor surface can be determined, or the above described distance SID can be calculated.

[Technique for Accurately Calculating the Dose of Radiation to which a Subject has been Exposed]

Concerning the above described irradiation apparatus **20**, there are many cases where a DAP (Dose Area Product) meter for measuring a dose area product of radiation emitted from the irradiation apparatus **20** is attached to the irradiation apparatus **20**. However, while the dose area product of radiation emitted from the irradiation apparatus **20** is measured with this DAP meter, the dose area product of radiation emitted to the patient as the subject or the dose of radiation to which the subject has been exposed cannot be accurately determined with the DAP meter.

In this case, for example, the field of radiation emitted from the irradiation apparatus **20** is narrowed. As shown in FIG. **20**, if radiation is emitted so that all the emitted radiation enters the cassette-type detector D via a subject H (or if radiation is emitted so that the emitted radiation does not leak out of the cassette-type detector D), a captured image is analyzed to calculate the area of the region Ra of the imaged subject H and the area of the region Rb outside the imaged subject H, and the actual dose of radiation to which the patient as the subject H has been exposed can be calculated by multiplying the dose area product measured with the DAP meter by Ra/(Ra+Rb).

In actual imaging, however, radiation is not necessarily emitted so that the field of radiation emitted from the irradiation apparatus **20** falls within the cassette-type detector D as described above. Therefore, in any type of imaging, there is a demand for development of a technique for accurately calculating an actual dose of radiation to which a subject H has been exposed. In view of such circumstances, the inventor made studies on techniques and the like for accurately calculating the dose of radiation to which a subject H has been exposed. As a result, the inventor has discovered that such a technique can be realized with the structure described below.

In a case where imaging is performed with a cassette-type detector D installed in the above described imaging stand **1**, for example, a radiation sensor **30** that detects radiation emitted from the irradiation apparatus **20** is provided between the irradiation apparatus **20** and the imaging stand **1**, as shown in FIG. **21**. At this point, the radiation sensor **30** is attached to a supporting plate **31**, for example, and is designed to move two-dimensionally on a predetermined virtual plane S_S in the real space when the supporting plate **31** is moved by a moving device (not shown).

It should be noted that the distance rs between the radiation sensor **30** and the focal point F of the radiation source of the irradiation apparatus **20** is known in advance. Alternatively, the radiation sensor **30** can be designed to be movable only in the vertical direction (or one-dimensionally), for example, and estimate the horizontal range of radiation emitted from the irradiation apparatus **20** in accordance with the vertical range of radiation to be emitted from the irradiation apparatus **20** and the horizontal-to-vertical ratio of the radiation field set by the collimator **21** of the irradiation apparatus **20**, the vertical range of the radiation emitted from the irradiation apparatus **20** being detected by the radiation sensor **30** as described below. In this case, the supporting plate **31** to which the radiation sensor **30** is attached can be the covering plate of a covering plate unit for long-time imaging disclosed in JP 2013-154146 A (see the covering plate 61 of the covering plate unit 60 in the publication), for example. It is also possible to employ more than one radiation sensor **30**.

In a situation where the radiation sensor **30**, the supporting plate **31**, and the like are removed from the space between the irradiation apparatus **20** and the imaging stand **1**, for example, the distance SID between the focal point F of the radiation source of the irradiation apparatus **20** and the cassette-type detector D installed in the imaging stand **1** is measured at the time of or prior to imaging. Here, the distance SID may be measured by the above described measurement technique or may be measured by some other method. At the time of imaging, the diaphragm of the collimator **21** of the irradiation apparatus **20** is automatically adjusted by the irradiation apparatus **20** or is manually adjusted by a radiological technologist or the like watching the visible light emitted from the irradiation apparatus **20** as in conventional cases. In this manner, the radiation field is adjusted so that radiation is appropriately emitted to the patient as the subject H.

In that situation, the patient as the subject H is temporarily removed from the position in front of the imaging stand **1**, and the irradiation apparatus **20** is caused to emit radiation (the amount of the radiation emitted here is a radiation dose that can be detected by the radiation sensor **30**). The radiation sensor **30** is then moved two-dimensionally or one-dimensionally, and the vertical range and the horizontal range of the radiation emitted from the irradiation apparatus **20** are measured. When actual imaging is performed with radiation emitted to the subject H, an image of the subject H and others is captured by the depth camera **23** or some other imaging unit.

As described above, the distance SID between the focal point F of the radiation source of the irradiation apparatus **20** and the cassette-type detector D installed in the imaging stand **1** has been measured and is already known, and the distance rs between the radiation sensor **30** and the focal point F of the radiation source of the irradiation apparatus **20** is also already known. Accordingly, based on the emitted radiation ranges measured in the above described manner, it is possible to identify the radiation range Rall at the distance SID from the focal point F of the radiation source of the irradiation apparatus **20** (or the distance SID at which the cassette-type detector D is located) in the captured image, as shown in FIG. **22**.

As a result of an analysis of the image, the area of the region Rc of the imaged subject H and the area of the region Rd outside the imaged subject H can be calculated. Accordingly, the actual dose of radiation to which the patient as the subject H has been exposed can be accurately calculated by multiplying the dose area product measured with the DAP meter by Rc/(Rc+Rd).

As described above, with the above described structure (see FIG. **21**) newly developed by the inventor, it is possible to accurately calculate the actual dose of radiation to which the patient as the subject has been exposed (or the dose area product of radiation actually emitted to the patient). Accordingly, the actual dose of radiation to which the patient has been exposed is accurately recognized, and the patient is prevented from being exposed to a larger dose area product of radiation than necessary. Thus, the dose of radiation to which the patient is exposed can be reduced.

[Increasing Power while Minimizing the Focal Point of the Radiation Source]

In the irradiation apparatus **20** (see FIG. **18** and others) that emits radiation to a panel D (or a cassette-type detector D such as an FPD cassette or a CR cassette) installed in the imaging stand **1**, the radiation source **40** or the like that generates radiation is provided as described above. As shown in FIGS. **23**A and **23**B, for example, the radiation source **40** is designed to generate radiation such as X-rays at the focal point F by emitting an electron beam B from an electron gun **42** located below the focal point F, toward a region in a tilted surface **41***a* of a rotating anode **41** or toward the focal point F.

FIG. **23**A is a view of the rotating anode **41** and other components of the radiation source **40**, seen from the subject. FIG. **23**B is a view of the rotating anode **41** and other components, seen from the left in FIG. **23**A. In FIGS. **23**A and **23**B, the size of the focal point F is very large in relation to the size of the rotating anode **41** and other components, for easier visual recognition of the shape of the focal point F. The same applies in the respective drawings to be later referred to. Therefore, the electron beam B shown in FIG. **23**B is not much narrowed by an electron lens **43**, for example. In reality, however, the electron beam B is narrowed so that the diameter of the focal point F becomes several hundreds of μm, for example. Furthermore, it goes without saying that the electron beam B is not reflected at the position of the focal point F on the tilted surface **41***a* of the rotating anode **41**, but the focal point F irradiated with the electron beam B serves as the source of radiation emission. Accordingly, radiation is emitted in all directions from the focal point F, and is collimated by the above described collimator, so that the radiation is emitted forward in FIG. **23**A (and rightward in FIG. **23**B), for example.

If the extent of the focal point F is too large, an image captured through emission of radiation from the radiation source **40** to the panel D via the subject is blurred. Therefore, the radiation source **40** is required to reduce the extent of the focal point F, or to make the focal point smaller.

However, if the focal point F is made too small, only a portion of the tilted surface **41***a* of the rotating anode **41** that is rotating is irradiated with the electron beam B as shown in FIG. **24**, and the portion is linearly damaged (see the line L in FIG. **24**), resulting in shortening of the life of the rotating anode **41**. Therefore, when the focal point is made smaller, the energy of the electron beam B should be reduced, and the power of the radiation to be emitted from the radiation source **40** needs to be lowered. In a case where the power of the radiation source **40** is to be increased, the focal point F has to be enlarged so as not to damage the tilted surface **41***a* of the rotating anode **41** as described above. That is, the focal point needs to be made larger.

The electron lens **43** that narrows the electron beam B emitted from the electron gun **42** has limited ability to narrow the electron beam B due to aberration that depends on the energy of the electron beam B. Therefore, at present, the radiation source **40** in many cases is designed to choose between radiation emission to a small-sized focal point at low power and radiation emission to an enlarged focal point at high power.

As shown in FIG. **25**A, a side surface **41***b* of the rotating anode **41** is not tilted (so that the normal line of the side surface **41***b* extends in the horizontal direction), and an electron beam B having the same diameter as the electron beam B shown in FIG. **23**B is emitted to the side surface **41***b*. As a result, the apparent diameter of the focal point F in the vertical direction becomes larger as shown in FIG. **25**B. On the other hand, where the rotating anode **41** has the tilted surface **41***a* on which the electron beam B is to be emitted, and the electron beam is emitted to the tilted surface **41***a* as shown in FIG. **23**B, at least the apparent diameter of the focal point F in the vertical direction can be made smaller as shown in FIG. **23**A. It should be noted that the actual diameter A of the focal point F in FIG. **25**A is the same as the actual diameter A of the focal point F in FIG. **23**B.

As described above, the radiation source **40** at present is devised to make the focal point F smaller at least in the vertical direction even when emitting radiation at high power. However, when radiation is emitted at high power, the focal point F cannot be made smaller in the horizontal direction, and it is still necessary at present to choose between low power with a smaller focal point and high power with a larger focal point.

In view of such circumstances, the inventor made studies on methods and structures for increasing power while reducing the size of the focal point of the radiation source. As a result, the inventor has discovered that this can be realized with the structure described below.

Specifically, where the rotating anode **41** and other components of the radiation source **40** are seen from the subject, as shown in FIG. **23**A, the conventional radiation source **40** or the radiation source **40** at present forms the focal point F by emitting the electron beam B to the center position in terms of the horizontal direction on the rotating anode **41**. In a radiation source **40*** having a structure newly developed by the inventor, on the other hand, the position in which a focal point F is to be formed is changed to the left edge position (or the right end position; this applies in the description below) of the rotating anode **41** in terms of the horizontal direction, as shown in FIG. **26**A. Instead of the tilted surface **41***a* of the rotating anode **41** of the conventional radiation source shown in FIG. **23**A, a non-tilted side surface **41***b* is formed as the surface of the rotating anode **41** to which the electron beam B is to be emitted, as shown in FIG. **26**A.

FIG. **26**B shows a state where the rotating anode **41** and other components shown in FIG. **26**A are seen from the left in FIG. **26**A. The state shown in FIG. **26**B is similar to the state shown in FIG. **25**B. However, while radiation is emitted forward from the focal point F of the rotating anode **41** in the case shown in FIG. **25**B, radiation is emitted rightward in the case shown in FIG. **26**B. Also, while radiation is emitted rightward from the focal point F of the rotating anode **41** in the case shown in FIG. **25**A, radiation is emitted forward from the focal point F of the rotating anode **41** in the case shown in FIG. **26**A.

When seen from the subject to which radiation is to be emitted, as shown in FIG. **26**A, the focal point F of the rotating anode **41** of the radiation source **40*** appears to be elongated in the vertical direction, and thus, the focal point F is made smaller in the horizontal direction. Furthermore, since the extent of the focal point F is large as shown in FIG. **26**B, the energy of the electron beam. B emitted to the rotating anode **41** can be made greater. With the above described structure, the radiation source **40*** can be made a high-power radiation source, while the focal point F is made smaller in the horizontal direction.

In short, in the radiation source **40*** having the structure newly developed by the inventor, the electron beam B with high energy is emitted from the electron gun **42** to a relatively wide region on the side surface **41***b* of the rotating anode **41** as shown in FIG. **26**B, and the power is increased. However, radiation is not emitted in the direction in which the focal point F is seen from the front as shown in FIG. **25**B, but radiation is emitted in the direction in which the focal point F is seen from a side as shown in FIG. **26**A. With this structure, the apparent diameter of the focal point F is made smaller in the horizontal direction, and the size of the focal point F is made smaller in the horizontal direction. In this manner, in the radiation source **40*** having the structure newly developed by the inventor, the power is increased while the size of the focal point F is made smaller in the horizontal direction.

It should be noted that the side surface **41***b* of the rotating anode **41** of the radiation source **40*** does not need to be perpendicular to the upper surface and the lower surface of the rotating anode **41**, but may be tilted at an appropriate angle. Although the electron beam B is emitted horizontally to the side surface **41***b* of the rotating anode **41** in FIG. **26**A, the electron beam B may be emitted from above or below to the side surface **41***b*.

Alternatively, as shown in FIG. **27**, the rotation axis of the rotating anode **41** may be tilted so that the tilted surface **41***a* of the rotating anode **41** faces in the vertical direction or an almost vertical direction in the left edge position (or the right edge position) (or the normal line of the tilted surface **41***a* in that position extends in the horizontal direction or an almost horizontal direction), for example. The electron beam B is then emitted to that position. In FIG. **27**, radiation is also emitted forward from the focal point F of the rotating anode **41**.

In either case, in the radiation source **40*** having a structure newly developed by the inventor, the position of the focal point F formed by emitting the electron beam B to the center position in terms of the horizontal direction on the rotating anode **41** of a conventional radiation source is changed to the left edge position or the right edge position on the rotating anode **41** in terms of the horizontal direction, and the focal point F is formed by emitting the electron beam B to the left edge position or the right edge position on the rotating anode **41** in terms of the horizontal direction, with the rotating anode **41** and other components being seen from the subject (see FIG. **26**A and FIG. **27**). With this structure, the apparent diameter of the focal point F is made smaller in the horizontal direction, and the size of the focal point F is made smaller in the horizontal direction. At this point, the apparent diameter of the focal point F in the horizontal direction remains small even when the electron beam B with great energy is emitted. Accordingly, the power can be increased while the size of the focal point F is made smaller in the horizontal direction.

In the above described structure, the apparent diameter of the focal point F of the rotating anode **41** becomes smaller in the horizontal direction, but neither the diameter nor the apparent diameter of the focal point F becomes smaller in the vertical direction. In view of this, a slit **50** is provided on the output side of the rotating anode **41** of the radiation source **40***, to restrict vertical spread of the radiation emitted from the rotating anode **41**, as shown in FIG. **28**. In this state, radiation is emitted to the imaging device D via the subject (not shown). In FIG. **28**, the focal point F on the rotating anode **41** is shown in the form of a line as a linear light source.

The radiation emitted from the radiation source **40*** is then moved in the horizontal direction in the state shown in FIG. **28**. In this manner, an irradiation apparatus of a so-called line scanning type can be formed with the use of the radiation source **40***. As described above, in the radiation source **40*** having a structure newly developed by the inventor, power can be increased while the size of the focal point F is made smaller in the horizontal direction. Accordingly, imaging is performed by emitting high-power radiation with a small-sized focal point from the radiation source

40* of such a line-scanning irradiation apparatus. Thus, a clear, unblurred image of the subject can be captured.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustrated and example only and is not to be taken by way of limitation, the scope of the present invention being interpreted by terms of the appended claims.

What is claimed is:

1. An imaging stand comprising:

a holder having four rectilinear sides and configured to mount therein a cassette-type detector, the cassette-type detector having a radiation incidence surface, the holder being rotatable around a rotation axis perpendicular to the radiation incidence surface, the rotation axis passing perpendicularly through the radiation incidence surface;

a supporting member configured to support the holder from a back surface side of the holder;

a circular gear secured to a shaft member attached to the holder and protruding from a rotation center of the holder, the shaft member extending perpendicularly from a back surface side of the holder, the rotation center of the holder being located in a different position from a position corresponding to the center of the radiation incidence surface of the cassette-type detector held in the holder, the circular gear having a plurality of teeth; and

a linear gear having concavities and convexities to be engaged with the teeth of the circular gear, the linear gear being attached to the supporting member,

wherein, when the holder holding the cassette-type detector is rotated within a first plane around the rotation axis relative to the supporting member, the rotation center of the holder linearly moves within the first plane relative to the supporting member as the holder rotates, the center of the radiation incidence surface does not move by rotation, and a change is caused in orientation and position of the cassette-type detector.

2. The imaging stand according to claim 1, wherein the linear gear is oriented in a second plane parallel to the first plane at a 45 degree angle relative to the sides of the holder, and wherein the linear gear and the circular gear are configured so that, when the holder is rotated around the rotation axis by 90 degrees in a first rotational direction relative to the supporting member to a first position, the center of the radiation incidence surface moves linearly along a first line.

3. The imaging stand according to claim 2, wherein the cassette-type detector held in the holder is a cassette-type detector of 14×17 inches in size, and wherein when the holder is rotated around the rotation axis by 90 degrees in the first rotational direction relative to the supporting member from the first position, the center of the radiation incidence surface moves linearly along a second line perpendicular to the first line.

4. The imaging stand according to claim 1, wherein, when the holder holding the cassette-type detector of 14×17 inches in "portrait" orientation and position is rotated 90 degrees relative to the supporting member, the cassette-type detector of 14×17 inches is placed in "landscape center" orientation and position.

5. The imaging stand according to claim 2, wherein, when the holder holding the cassette-type detector of 14×17 inches in the "portrait" orientation and position is rotated 90 degrees in reverse direction relative to the supporting member, the cassette-type detector of 14×17 inches is placed in "landscape top" orientation and position.

6. The imaging stand according to claim 3, wherein, when the holder is rotated 180 degrees relative to the supporting member, the holder is placed in a position where the cassette-type detector of 17×17 inches can be installed.

7. The imaging stand according to claim 1, further comprising a slide plate slidably mounted to a side of the holder.

8. The imaging stand according to claim 7, further comprising a rod-shaped member, a first end of the rod-shaped member being attached to the slide plate, wherein the slide plate is slidably mounted to the holder using the rod-shaped member.

9. The imaging stand according to claim 8, wherein a second end of the rod-shaped member is attached to the supporting member.

10. The imaging stand according to claim 9, wherein the rod-shaped member and the slide plate are configured so that, when the holder is rotated, the slide plate moves relative to the holder.

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